Compressed Air Magazine

Vol. XXXVII, No. V London New York Paris 35 Cents a Copy

MAY, 1932

CIRCULATION THIS ISSUE
28,692 *COPIES*

Ewing Galloway, New York

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Norman S. Gallison

Bush Terminal—Crossroads of Commerce
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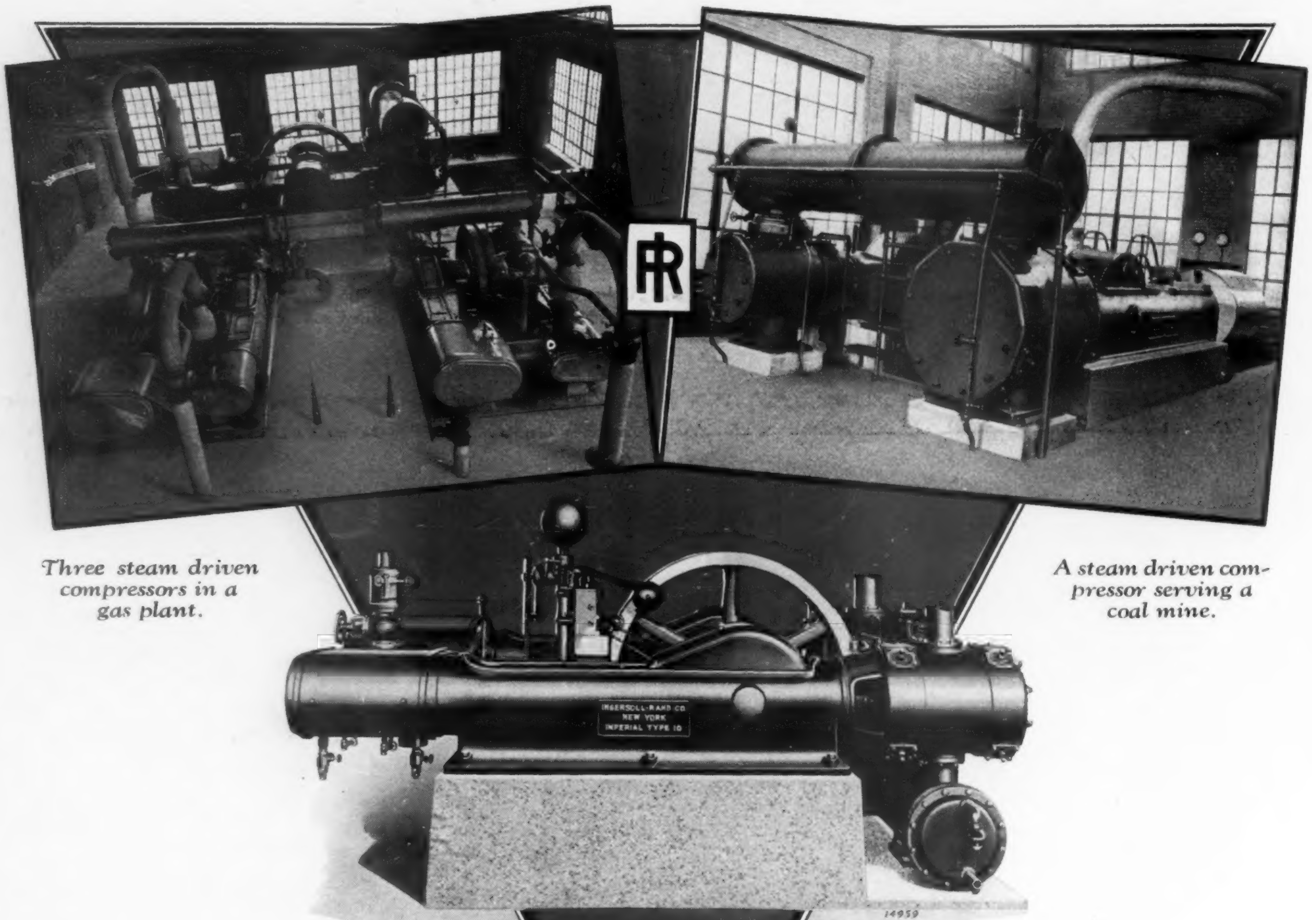
A 40% Saving in Steam Consumption



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As It Seems To Us

OUT OF THE LABORATORIES

SIMULTANEOUSLY with the forecast that the United States will have a 360,000-ton surplus of sugar during 1932, came the announcement at the annual meeting of the American Chemical Society that the tensile strength of lime mortar can be increased 60 per cent by the addition of 6 per cent sugar, by weight. Thus does scientific research move to balance the supply and demand of a natural product.

This discovery is credited to chemists of the Mellon Institute of Industrial Research. It is actually centuries old, it having been definitely established that the Romans sweetened their mortar. However, no one seems previously to have taken the trouble to find out why they did so. The present investigators have conducted exhaustive tests calculated to show the effect of various amounts of sugar under a wide range of conditions. Their conclusion is that maximum benefit is obtained by dissolving the sugar in water and adding it to the lime after it has been slaked. The finding may prove a distinct boon to sugar producers.

Other interesting and enlightening reports were made public at this meeting of chemists. One such revealed that oil from the liver of the halibut is richer in vitamins A and D than that from any other fish known. The sacred cod may lose some of its caste as a result.

Another surprising revelation places cottonseed oil in the category of a gasoline producer. By cracking the oil—breaking it down under heat and pressure, it can be made to yield not only an efficient anti-knock gasoline but also a variety of other hydrocarbons ranging from fuel oil to thirteen different gases. Alcohol likewise is a derivative. The cost is now too high to allow these products to be commercially competitive; but no doubt the future will change this.

Periods of slack business are always times of feverish research activity. Increased importance attaches to new ways of doing things that will cut established costs. The tighter the shoe, the more effort is expended to relieve its pressure.

HELLO WORLD!

BY MEANS of the telephone and the radio it is possible now to talk to virtually the whole world. The linking together of the telephone systems of the various continents has proceeded to the point where any two of more than 33,000,000 instruments can be quickly connected. This number represents about 93 per cent of the telephones in existence.

Transoceanic telephony has been developed to the stage where reliable service can be obtained 90 per cent of the time. The average number of daily calls during the first year these communication facilities were offered was seven. More than 100 calls are now made on some days, and last Christmas 342 messages of good cheer spanned the Atlantic. Conversations lasting as long as 97 minutes have been carried on between New York and London. An American tourist who became ill in France rang up the family doctor in New Orleans for advice. Three million gallons of gasoline were sold in Europe as a result of a call from Tulsa, Okla.

North and South America, the British Isles, most of Europe, one city in Africa, and numerous insular areas are today in a common network of communication. Millions of dollars have been spent on sending and receiving stations by which land wires are joined to radio waves for crossing water stretches. The process employed provides for scrambling messages so that they will be unintelligible to anyone who intercepts them. Two-way transmission is accomplished by means of separate circuits several hundred miles apart. Interference between circuits is eliminated by storing up a certain portion of the talk for a time, thus permitting one circuit to be disconnected while the other is in operation. Two forms of radio transmission are available—long-wave or short-wave directed beams, the choice depending upon the nature of the prevailing atmospheric electrical disturbances that must be overcome. Each has its limitations.

FOR SIMPLER SPECIFICATIONS

THE magazine *Power* sounds the tocsin for simpler specifications covering the purchase of equipment and services by governments and private firms. This is a movement that will undoubtedly have the whole-hearted sympathy and support of all concerns that have had experience in trying to live up to the letter as well as to the spirit of legal documents which are shot through with restrictive but irrelevant clauses.

Well taken is the point that "the simple specification that indicates what is to be done, the grades of equipment and results desired, and thereafter leaves room for real coöperation between buyer and seller, will always win in price and accomplishment."

The bickerings and delays, which are produced by the binding and arbitrary technicalities so often found in the forms used, cost buyers a staggering amount of money each year. Manufacturers and suppliers of equipment and services have learned that they must set up adequate profit margins to cover these contingencies.

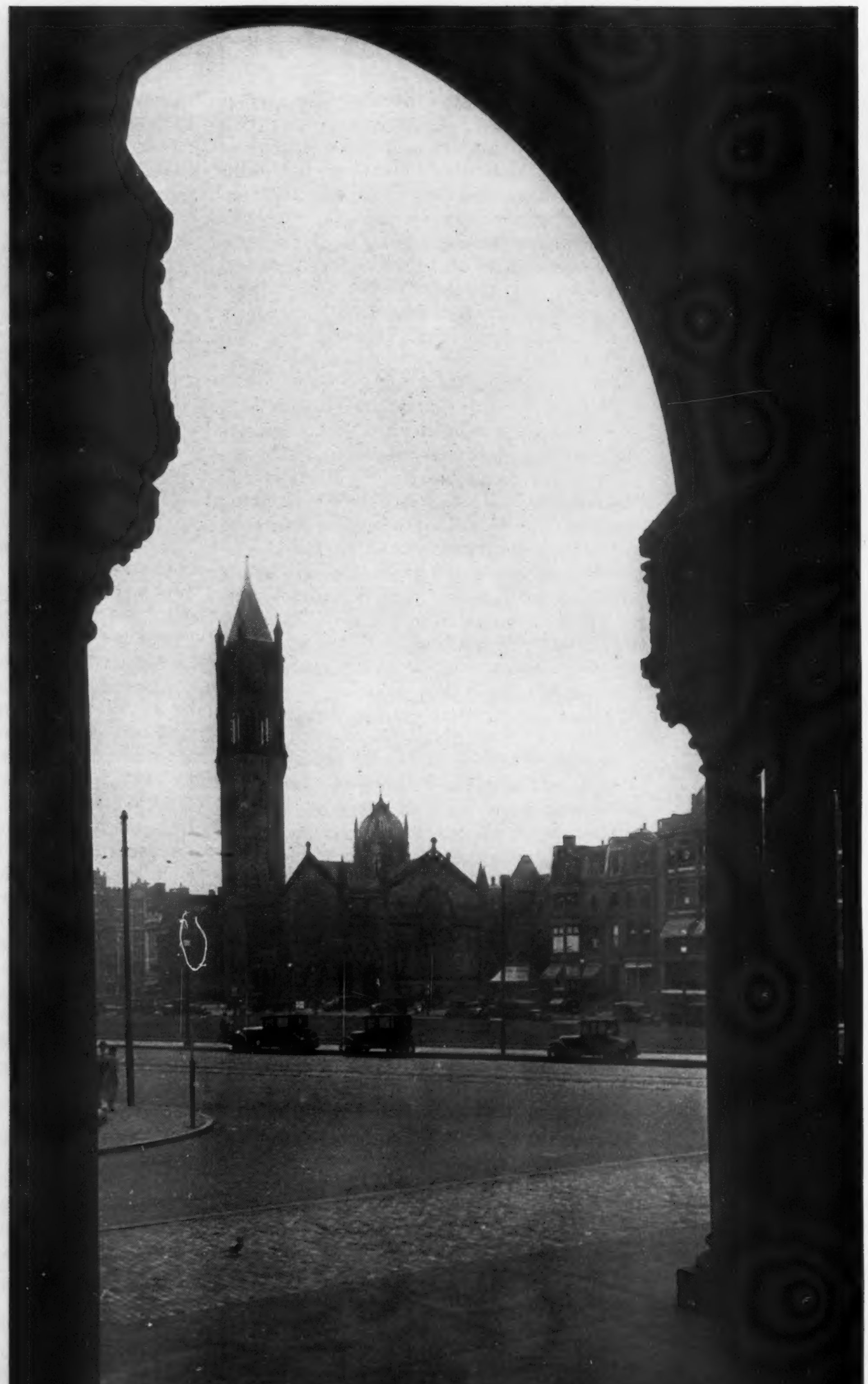
When governments and private corporations are made aware that they can save money by cutting red tape, they will no doubt be willing to do so. Certainly it must be apparent to a railroad official that he cannot put locomotives and air compressors in the same measuring device, yet this is what is now often attempted.

WHY WINTERS ARE WARMER

IS OUR climate changing? This question has recurred in the northern portion of the United States with the mildness of the past winter. The truth about the matter is that the climate is continually changing, and that there is nothing strange or surprising in that fact. The geologist and the paleontologist, reading the abundant records left by past ages, long since established that the north-temperate latitudes have been visited, alternately, by eras of cold and warmth. If the old order persists, and there is good reason to assume that it will, climatic changes can be expected to continue.

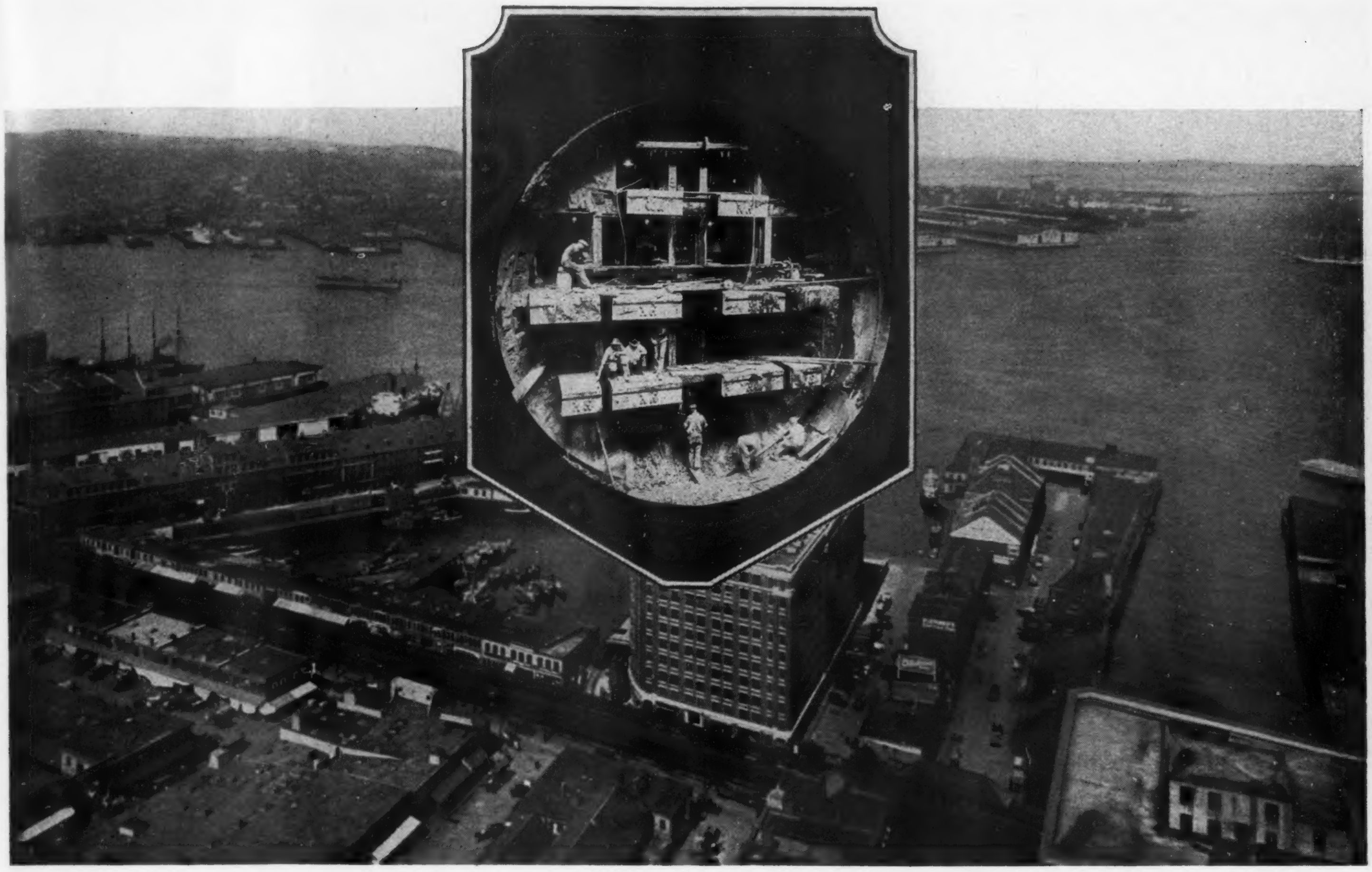
The era in which we are living appears to be an interval between two glacial periods, such as occurred several times during the Pleistocene epoch, which was the last great ice age. Sometime within the next few thousand years, tongues of ice may creep down from the Northland and spread over much of the territory which was thus covered in bygone geological periods. There is evidence to support the theory that we are now in a backswing from the last glacial age, and that the pendulum will continue its travel until we experience semi-tropical climate. Whether that balminess will remain, or whether there will again come a transition back to a frigid existence, is something that our progeny several thousand generations removed will learn.

Meanwhile, there is definite indication that less harsh winters are becoming the regular thing. Maj. W. A. WELCH, general manager of the Palisade Interstate Park which is maintained by the states of New York and New Jersey, reports that typically northern plants and animals are slowly migrating back toward the Arctic Circle before the advance of warmer winters. At the same time, he declares, warm-climate species are creeping northward. Spruce, cedar, and larch trees, which are known to have abounded in the highlands along the Hudson River 300 years ago, are today little in evidence there. In areas where they have been cut over by man, they have not returned. On the other hand, the prickly pear cactus, which was formerly absent, is slowly encroaching upon that section and is now crowning rocky knobs amid the oak, birch, and maples. Another example is the southern bald cypress. Although not normally found north of Virginia, it is flourishing at one point on the Hudson.



Ewing Galloway

Old South Church, Boston, viewed through an arch of Trinity Church.



Ewing Galloway

The tunnel will cross beneath the water at the upper left. The insert shows the front end of the shield.

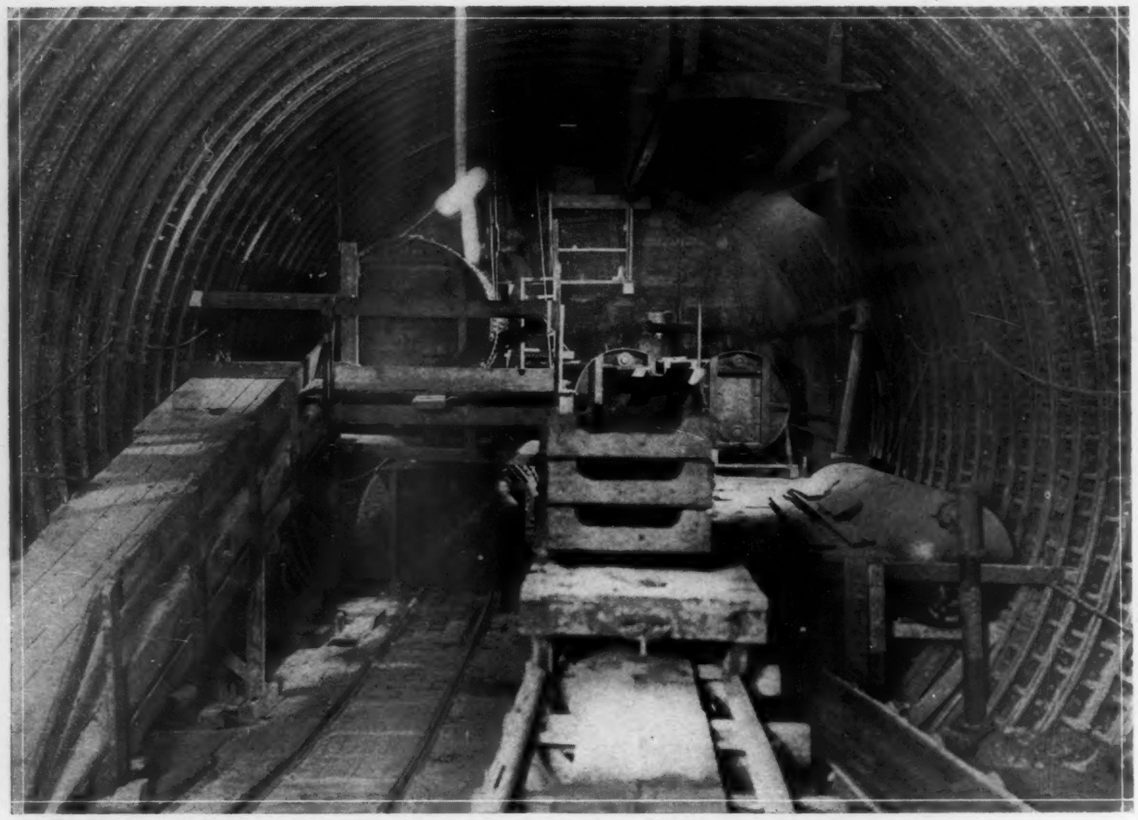
Boston Builds a Subaqueous Vehicular Tunnel at Record Speed

C. H. VIVIAN

PROMPTED by the signal success of the Holland Tunnel between New York and New Jersey, the City of Boston is now engaged upon the construction of an underwater passage of similar general design which will provide a direct route for vehicles between Boston proper and East Boston. Crossing beneath the main ship channel of Boston Harbor, the tube will afford automotive traffic an unimpeded, high-speed travel artery. At present, cars may cross on either of two municipal ferry lines or follow a circuitous land route, largely over narrow streets, through Charlestown and Chelsea—a 15-minute trip under normal conditions, with the ever-present possibility of being held up at one or both of two drawbridges.

From an engineering standpoint there is little distinctly new or novel about the tunnel, but in the actual burrowing of the subaqueous channel the contractor has introduced certain departures from traditional practices that are noteworthy for their time savings and their efficiency. Chief among these innovations is a method of removing excavated materials by mechanical conveyors. This is proving so successful that all existing records for driving a large-size tunnel through clay are being eclipsed. Of particular interest is the fact that muck is being moved continuously through a bulkhead which separates normal and high-pressure air zones. This is being accomplished by means of specially designed automatic air locks. Coördinated with these locks is the mechanical equipment which moves the spoils from the tunnel breast to trucks on the street, hundreds of feet away, without any semblance of manual handling and with scarcely any supervision. It is the nearest approach to robot tunneling that has ever been devised. But before describing this and other absorbing details of the work, we will sketch the chief general features of the undertaking.

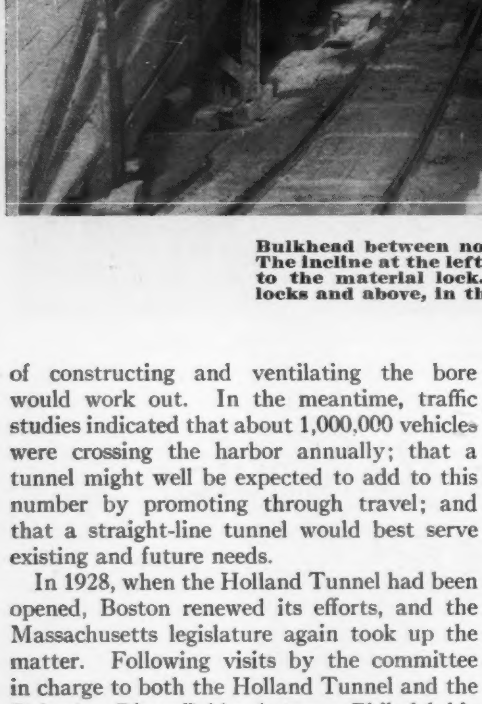
Construction of some avenue of direct communication between Boston and East Boston was first proposed 64 years ago when General Foster of the United States Army Engineers made investigations which led him to favor a tunnel rather than a bridge. In 1872, seven years before compressed air had been applied to underwater boring, he filed a report in which he outlined an ingenious scheme for digging a trench and laying the tunnel structure within it—thereby forecasting a method which has in recent years been successfully used at Detroit and elsewhere. Discussion of either a bridge or a tunnel cropped up from time to time during ensuing years, and several engineering studies were conducted without definite action being taken. It was fairly well established at an early date, however, that a bridge would be unsuitable for the dual reason that the Navy Yard was situated above the site of crossing and that bridge-building operations would restrict the free movement of boats plying the harbor. Determination that a tunnel would probably be driven eventually led to the proposal and consideration of many plans. Undoubtedly something definite would have been done in 1920 had it not been for the inception of the Holland Tunnel about that time. This caused the Boston authorities to postpone action until it had been learned how the New York plan



Bulkhead between normal and higher pressure air zones. The incline at the left leads to the man lock. The rails run to the material lock. At the right are the two muck locks and above, in the center, is the emergency man lock.

of constructing and ventilating the bore would work out. In the meantime, traffic studies indicated that about 1,000,000 vehicles were crossing the harbor annually; that a tunnel might well be expected to add to this number by promoting through travel; and that a straight-line tunnel would best serve existing and future needs.

In 1928, when the Holland Tunnel had been opened, Boston renewed its efforts, and the Massachusetts legislature again took up the matter. Following visits by the committee in charge to both the Holland Tunnel and the Delaware River Bridge between Philadelphia and Camden, a tunnel was definitely decided upon and, in 1929, an act was passed which empowered the city to proceed and authorized expenditures of $16,000,000. Preparation of the necessary engineering data then began under Chief Engineer Ernest R. Springer of the Boston Transit Commission, which organization has the enterprise in charge. The trench method of tunneling was considered and rejected because the War Department opposed it and also because it promised to add to the construction cost rather than to reduce it.



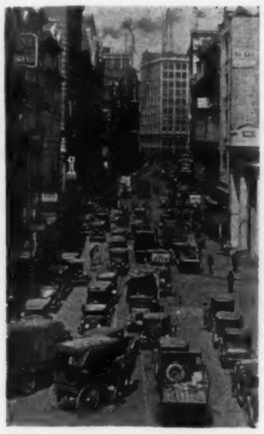
Position of tube and circular areas where streets are being widened. Dotted lines show present ferry lines and circuitous land route.

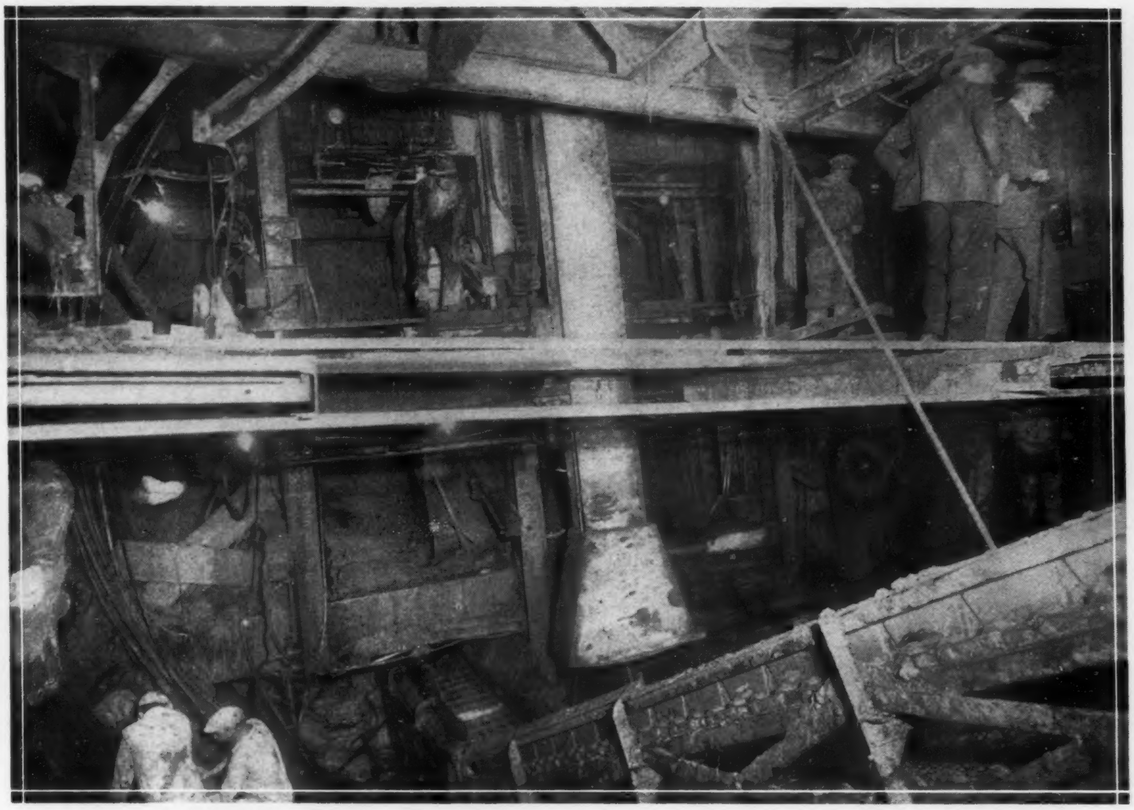
The East Boston Vehicular Tunnel, as it is officially known, will be a single fabricated-steel tube lined with concrete. It will extend a total distance of 5,650 feet between portals, of which 4,850 feet will be driven by shield. The remaining 800 feet at the two ends will consist of cut-and-cover box sections. The top of the tube will lie at a maximum depth of 50 feet below mean low water. On the Boston side the tunnel will follow a 4.2 per cent grade to the pierhead line, and on the East Boston side the corresponding section will have a slope of 3.4 per cent. The underwater section, approximately 1,600 feet between pierhead lines, will incline from either side toward the center on a grade of about 0.5 per cent. The outside diameter will be 31 feet, or 18 inches larger than that of the Holland Tunnel. A roadway 21½ feet wide at the curb line will afford ample room for two lanes of traffic—one in either direction—with sufficient space for passing a car that is forced to stop. There will be 13½ feet of headroom. The walls will be finished in tile; there will be a sidewalk for police usage; and facilities will be provided for emergency fire fighting.

The ventilating system will be similar to that of the Holland Tunnel, being designed to keep the carbon-monoxide content of the air always below 4 parts in 10,000. Housed above a ventilating shaft on either side of the water will be fourteen electrically driven fans—seven blowers and seven exhausters. Fresh air, to the amount of 1,200,000 cubic feet per minute, will be forced into the bore beneath the floor line and will be admitted to the roadway through ports spaced on 15-foot centers at the curb line. Vitiated air will be drawn out through openings in the ceiling, sucked back through the passage above the roadway, and exhausted at the ventilating shafts. The tunnel atmosphere will be completely changed 42 times an hour, or about once every 86 seconds.

Horse-drawn vehicles and pedestrians will be barred from the tunnel, which the Boston Public Works Department will operate on a toll basis. The charge has not been decided upon, but possibly may be 25 cents. It is estimated that at this figure the tunnel would lose money for about eight years, but thereafter would show a profit as a result of increased patronage and return the cost of construction with interest in about 25 years. Present indications are that it will be open for use early in 1934.

To facilitate the movement of traffic in and out of the tunnel, a street-widening program is being carried out within a radius of 1,000 feet from each portal. This phase of the





Rear of the shield, showing the apron conveyor which starts the clay on its journey out of the tube. Overhead is a monorail for moving up segments of steel lining. The erector arm which places them extends downward in the center.

work is well advanced under the direction of the Transit Commission and has involved the acquiring of much property and the razing of many buildings.

For construction purposes, the tunnel is divided into three parts. Chief among these is the shield-driven section of 4,850 feet, which includes the two ventilating shafts. This section is being built by Silas Mason Company, Inc., a New York firm which is well known in the subway-building field. Its bid was $5,696,510, approximately $600,000 less than the estimated cost. Work was started March 23, 1931, and is to be completed within two years from that date. Subsequently, the contract was amended to include the cut-and-cover section adjacent to the shield-driven section on the East Boston end. This consists of 368 linear feet of construction and was awarded on a bid of $260,000. The cut-and-cover work on the Boston end is being done by the C. & R. Construction Company of Boston under a $259,524.70 contract.

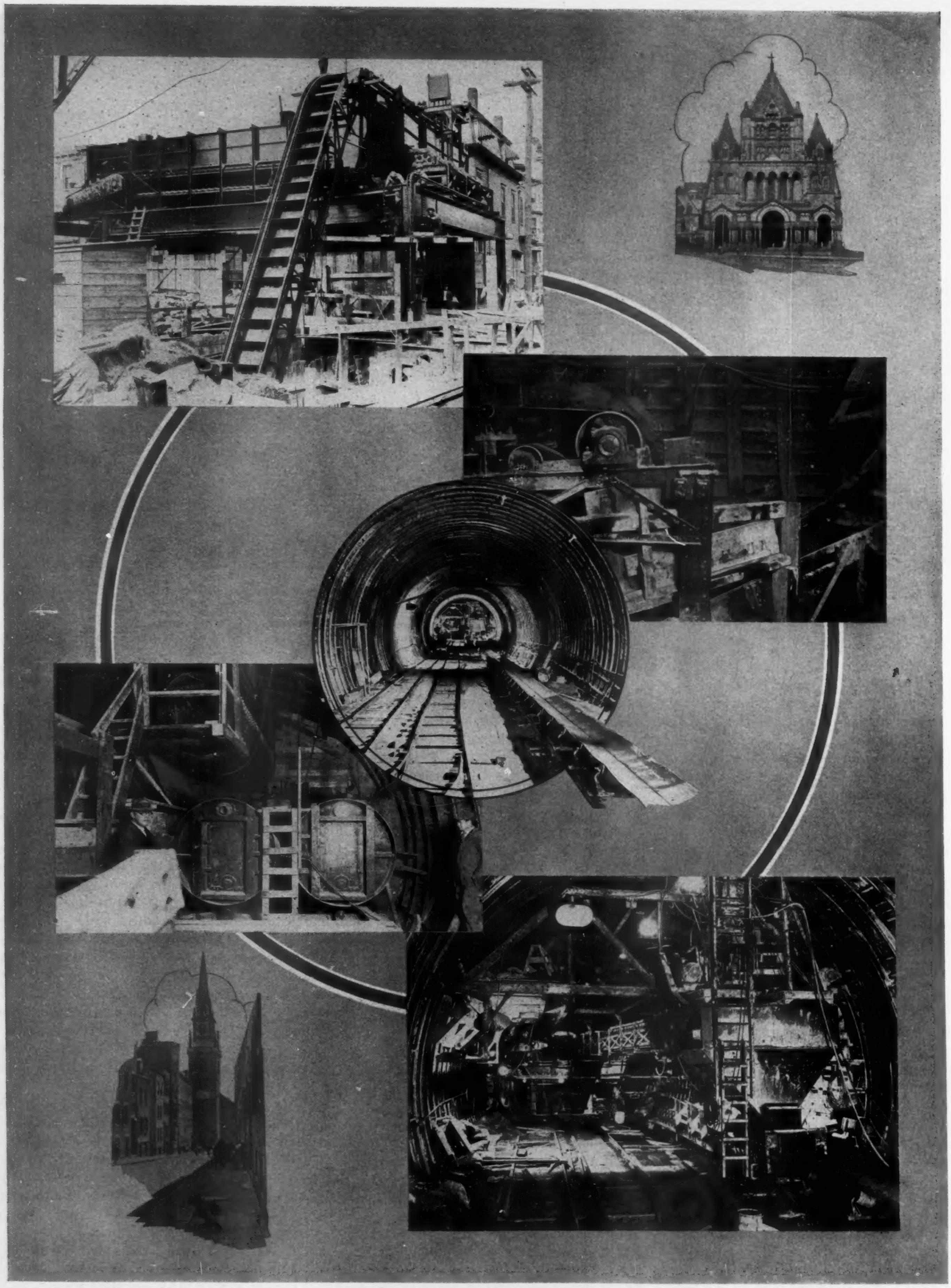
From the outset, Silas Mason Company has made remarkable progress as a result of thorough organization for the job and a display of willingness to deviate from the beaten path wherever possible to save time and money. Much pioneering has been done, and considerable financial risk has been taken. Fortunately, and to the credit of those on whose judgment and technical skill the decisions rested, this progressive spirit has been rewarded with success.

The contractor elected to start operations on the East Boston side and to drive from there to the opposite portal rather than to use two shields and work from both ends. The first step was the sinking and concreting of a shaft having a section of approximately 34x42 feet and a depth of 43½ feet. While this was in progress, the shield was being fabricated under contract; a power house to contain transformers, compressors, and hydraulic equipment was being constructed; and the multiplicity of other preparatory measures which such a job entails were being executed. Actual shield excavation began late in July, and the first pay ring of lining was placed on August 3. For four months thereafter work was carried on under normal air pressure. A reinforced-concrete bulkhead was erected at a point 1,100 feet in from the construction shaft; and on November 30, the breast having reached a point near the water, the workings were put under a pressure of 10 pounds to the square inch. This has been gradually increased to 24 pounds, which is believed to be the maximum that will be required.

The shield weighs 400 tons and is of conventional design. It has an outside diameter of 31 feet 7 inches, which leaves an annular space of 3½ inches between the tunnel lining and the excavated bore. This is filled with grout as the work progresses. The shield is 16 feet long and has a hood which projects 2 feet 9 inches in advance of the cutting edge at the top and extends down the sides for a distance of 8 feet. For moving it ahead, the shield is equipped with thirty 10-inch hydraulic jacks, each of which is capable of exerting a thrust of 150 tons. The interior of the shield has three working platforms spaced uniformly between the top and bottom. For shoving these platforms forward so as to give access to the working face there are ten 125-ton hydraulic jacks.

The pressure for operating these jacks is provided by Watson-Stillman hydraulic equipment in the power house. Two motor-driven, 12-inch-stroke plunger pumps build up a water pressure of 5,850 pounds per square inch. This water goes from the pumps to the accumulator, whose function it is to stabilize the pressure and to feed the water into the line as needed. It contains what is essentially a differential piston having a 48-inch stroke. Its larger diameter is 42 inches and its smaller one 8 inches. It is actuated by compressed air from the high-pressure line. The water is carried to the shield jacks by two 1½-inch lines designed to withstand a pressure of 8,000 pounds per square inch.

Soundings made by the contractor revealed that the cover over the top of the tunnel line varied from 9 to 15 feet. To give it a uniform



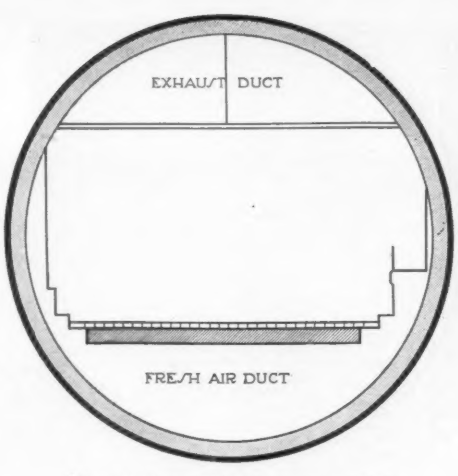
Principal elements in the conveying system. From bottom to top the pictures show, in order: apron conveyors and hopper back of the shield; automatic locks at bulkhead; belt conveyor; muck falling from conveyor belt on to scraper conveyor; scraper conveyor which elevates spoils to the surface for loading into trucks.

thickness of 15 feet, and thereby minimize the possibility of a "blow" from the tunnel air pressure, 7,645 cubic yards of clay was deposited from scows. It was distributed along 525 feet of the line.

For the most part the tunnel is being driven through clay varying from plastic to stiff; but small amounts of peat, sand, gravel, and bowlders have been encountered from time to time. The excavation methods have been modified at intervals to suit the materials met. For brief periods the face was so hard that six L-54 paving breakers and one L-67 "Jackhamer" were employed to break it out. Air-driven clay spades fitted with chisel-pointed blades were also used in such cases. The predominating tool, however, is the clay knife. For a time during the early stages of the work a mechanical arrangement for operating these knives was employed. At three levels on the shield there were mounted metal arms, each of which carried on its outer end a steel member running horizontally across the front of the shield and furnishing a support and guide for a knife. By means of cables the knives were drawn back and forth across the clay face, cutting off a slice of material at each passage. The cables were operated by Ingersoll-Rand Type 6HC double-drum air hoists, of which there were five on the job. Provisions were made for raising or lowering the knife-carrying members and for advancing them as excavation progressed. This method was successful, but was discontinued when changes in the material occurred.

The succeeding method, and the one now employed, uses the conventional clay draw knife which was developed in the Detroit area. It consists of a loop of iron with arms connected at the two sides and converging toward an eye for attachment of a pulling cable. One-half of the loop bears cutting edges: the other half is rounded for holding by the operator. The cable is passed around a sheave at the side of the shield and is pulled by an I-R No. 107 single-drum electric hoist. Guided transversely across the face of the clay breast by the operator, the knife cuts off a strip of material up to 10 inches thick and about 12 inches wide. As there are four working levels in the shield, that number of knives can be utilized simultaneously; and four hoists are set up at available locations within the shield. Air-driven clay diggers are used to excavate material around the edges which cannot conveniently be reached with the knives.

The clay is practically impervious, and the only water in the tunnel is that needed to operate the shield jacks. This is expelled through the bulkhead back in the bore by the difference in air pressure on the two sides of the barrier, and is pumped out of the tunnel by a Cameron No. 4LV pump.



The tube will have a 2-way traffic lane, 21½ feet wide, with air ducts above and below.

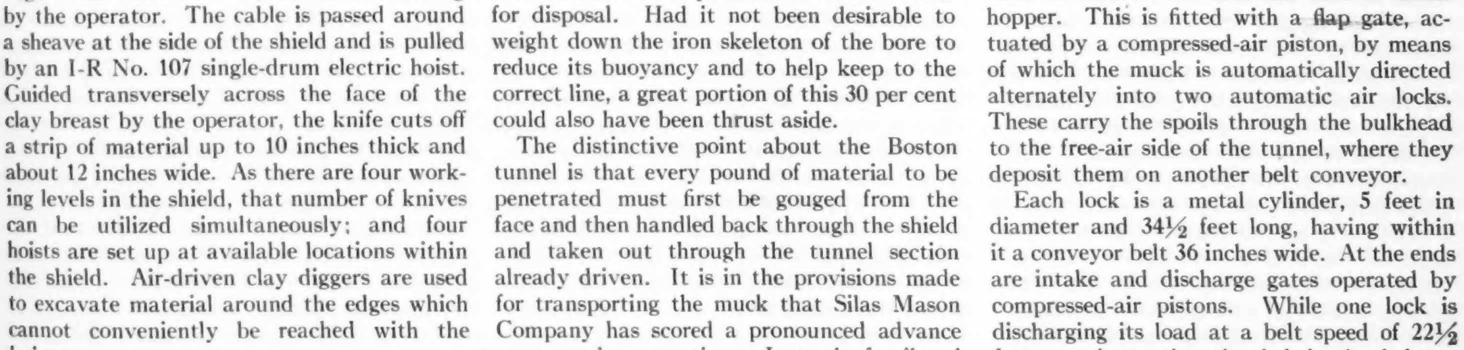
There is a notable difference between the driving of a shield tunnel in Boston and in New York Harbor, where the bulk of American subaqueous-bore experience has been accumulated. The bottoms of the Hudson and East rivers are composed largely of a fine silt which runs freely back through the openings in the shield when permitted to do so. The Boston clay, on the other hand, is an unyielding material which must be dug out before the shield can advance. In the driving of the Holland Tunnel, approximately 70 per cent of the silt along the tunnel line was pushed aside by the shield. The remaining 30 per cent was allowed to pour back into the tunnel for disposal. Had it not been desirable to weight down the iron skeleton of the bore to reduce its buoyancy and to help keep to the correct line, a great portion of this 30 per cent could also have been thrust aside.

The distinctive point about the Boston tunnel is that every pound of material to be penetrated must first be gouged from the face and then handled back through the shield and taken out through the tunnel section already driven. It is in the provisions made for transporting the muck that Silas Mason Company has scored a pronounced advance over previous practices. Instead of railroad cars—which require a maze of trackage and much supervision, which can move through locks slowly at best, and which are productive of much dirt and general confusion in the workings, H. L. Myer, vice-president and general manager of the company who is in charge of the operations, placed his faith in a conveyor system developed by L. F. Parker, mechanical engineer for the firm, with the gratifying results previously mentioned.

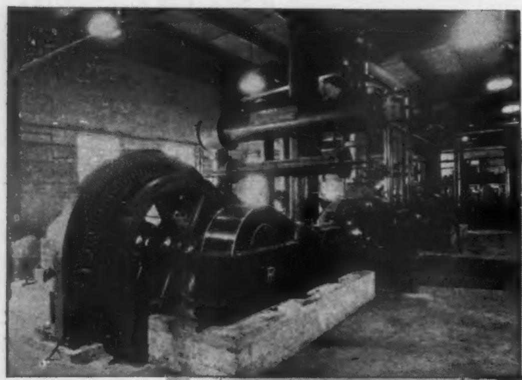
Some of the illustrations show various parts of this equipment; but a brief description will add to the reader's understanding of it. The slices of clay removed at the heading are broken by hand into pieces 12 to 30 inches long and dropped down chutes from any of the working levels of the shield. They fall upon one of two apron conveyors on either side of the shield. These conveyors are attached to the shield, and move forward with it. They are suspended rearward from the underside of a traveling steel platform, 60 feet long, which is supported on removable roller brackets secured to either side of the steel tunnel lining. These conveyors elevate the muck and deliver it to a large hopper placed over an endless belt conveyor 30 inches wide. For purposes of extending the latter as the work advances it has a special take-up section mounted on wheels which run upon rails laid on the temporary floor decking of the tunnel. Additional permanent sections of conveyor are provided as required. When the length has reached 1,500 feet, another conveyor with separate terminals is installed and arrangements are made for one belt to feed on to the next one in line.

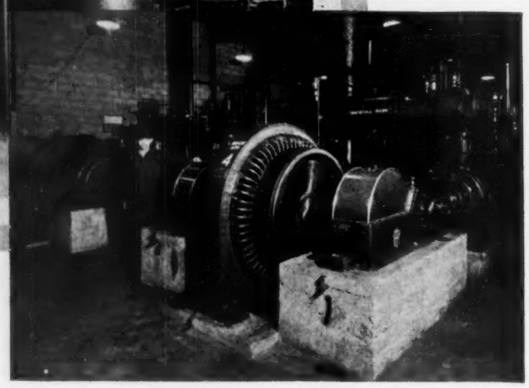
This conveyor is placed along one side of the tunnel where it occupies only a small part of the available floor width and leaves ample room for the railroad tracks over which storage-battery locomotives move supplies into the bore. At the bulkhead the conveyor rises to deliver the material into a metal hopper. This is fitted with a flap gate, actuated by a compressed-air piston, by means of which the muck is automatically directed alternately into two automatic air locks. These carry the spoils through the bulkhead to the free-air side of the tunnel, where they deposit them on another belt conveyor.

Each lock is a metal cylinder, 5 feet in diameter and 34½ feet long, having within it a conveyor belt 36 inches wide. At the ends are intake and discharge gates operated by compressed-air pistons. While one lock is discharging its load at a belt speed of 22½ feet per minute, the other is being loaded at a belt speed of 15 feet per minute. This speed



Sketch showing longitudinal section through tube.





Top—One of the three low-pressure compressors installed. Center—Equipment which supplies high-pressure water to the shield jacks. Right—Two compressors which furnish 100-pound air for the tunnel work.

variation provides the required interval between loading and unloading to operate the gates and to compress or decompress the locks, which latter functions are performed through the medium of electrically controlled thrustor-type valves. The entire operation is synchronized through electrical control. A pilot motor, acting through a series of change gears that permit varying the speed, actuates a shaft carrying cam-shaped disks which engage, at the proper intervals, the different contacts throughout the cycle. The whole system is provided with complete interlocks—either by time relays, limit switches, or pressure regulators—which eliminate the possibility of gates on opposite sides of the bulkhead being open at the same time, thereby releasing the pressure in the tunnel. The various elements in the conveyor system are driven by individual electric motors. The complete operating cycle of a lock consumes 141 seconds. Using low-pressure air, it takes about twelve seconds to compress a lock after unloading. High-pressure air would, it is estimated, reduce this time to four or five seconds.

Approximately 1,050 feet of conveyor belt moves the muck at a speed of 150 feet per minute from the bulkhead to the excavation shaft. There it falls upon a scraper-type conveyor which elevates it and delivers it either directly into trucks or into any one of three storage bins fitted with slow-traveling apron conveyors. These prevent the clay from piling up at one point and also facilitate loading into trucks, since the material is so sticky that it will not readily run through a hopper or chute and must fall with free space about it. Gates which control the loading into trucks are operated by compressed air. Most of the excavated material is trucked to the Boston Municipal Airport, where it serves as fill.

The tunnel lining is of steel, which material was employed for the first time in the Detroit-Windsor vehicular tunnel. It weighs only about one-third as much as the cast-iron lining traditionally used for such bores. While its cost per pound is slightly higher, it is reported to effect an over-all saving of more than $1,500,000 a mile. Each ring of lining is made up of eleven segments of standard design and of a key segment. The standard segments are 8 feet 10¼ inches long and 30 inches wide. They consist of a web, ⅜-inch thick, which conforms to the curvature of the tunnel, with welded flanges along its four edges. Lengths of 45-pound rail, spaced about 12 inches apart across each segment, stiffen the assembled ring longitudinally to withstand the force of the jacks, which bear against its forward edge at each shove of the shield.

The erection of each additional ring advances the tunnel lining 30 inches. The ring is assembled within the protective envelope of the shield tail, the segments being handled by an erector arm of conventional design mounted on the rear of the shield. The segments and rings are bolted together. Such bolting was formerly done manually, but in the Boston tunnel it is accomplished with air-driven wrenches which materially speed the operation. The tool to work in the limited space available was designed by Mr. Parker. It uses a standard air motor.

The annular space between the lining and the tunnel excavation is sealed by grouting. Each segment or plate of lining has a hole for this purpose. Following each shove of the shield, pea-gravel grout is forced through these openings with high-pressure air. At a point ten or twelve rings back, neat-cement grout is introduced. The efficiency with which this work is being done is attested to by the fact that about 3½ cubic yards of grout is being placed in each 3 cubic yards of theoretically available space.

Compressed air is, of course, vital to the undertaking, and a reliable compressor plant was one of the prime considerations of the contractor. The equipment provided consists of five Ingersoll-Rand Class PRE electric-driven units. Three of them are single-stage

types which supply the low-pressure air. Each has two 25x18-inch cylinders and is driven by a 450-hp. synchronous motor. Their combined piston displacement is slightly more than 12,000 cubic feet per minute. The two others are 20&12½x14-inch 2-stage machines, each driven by a 225-hp. synchronous motor and having a piston displacement of 1,302 cubic feet per minute. All five units are served by I-R Class M aftercoolers. The clearance valves which regulate the volume discharge of the low-pressure compressors are normally operated by air from the high-pressure units; but to provide service in case the latter are not running there is also installed an I-R Type 30 compressor driven by a 5-hp. motor. Two 6-inch high-pressure and two 10-inch low-pressure air lines extend from the power house into the tunnel. The low-pressure air is discharged at 30 to 40 pounds pressure into two 24-inch-diameter headers, 40 feet long, which act as receivers. As the tunnel is tight there is little leakage, and only a small portion of the compressor capacity is normally required to maintain the pressure.

As a result of the equipment devised and the methods developed, the tunnel is being advanced at a speed that probably would be impossible under former plans of procedure for such jobs. During a 24-hour day 32½ feet was excavated, which meant that the shield was shoved ahead thirteen times. In the same period twelve rings of lining, constituting 30 linear feet, was erected. This amount of excavating entailed the handling of 936 cubic yards of material, measured as compacted in the face. It would be a monumental job to haul it out of the tunnel in cars, yet it was removed without crowding the capacity of the conveyor equipment. Occasional enforced shutdowns are the rule on such work; but in this case none has been found necessary which cost the loss of more than one ring of lining.

The work beyond the bulkhead is being carried on by a force of men of whom 90 per cent had never been under air pressure before. This is because the legislative act limits employment to Massachusetts residents. They soon grew accustomed to the conditions; and are proving efficient. Under a bonus system, each man below the grade of foreman receives $1 extra every week for each ring above 45 that is erected. This has proved lucrative to the men, as is evidenced by the fact that in February, when a 545-foot advance was made, the average number of rings placed weekly was more than 52. Under the present air pressure of 24 pounds, the shift for each man is six hours of two periods of three hours each, with an interval of three hours. Work is conducted six days a week.

In direct charge of the work for Silas Mason Company, Inc., are Sam A. Mason, president, and H. L. Myer, vice-president and general manager. H. M. Buck is job engineer, and Frank Smith superintendent and general master mechanic. Commissioners of the Boston Transit Department, which has this work in hand, are Col. Thomas F. Sullivan, chairman, Nathan A. Heller, and Arthur B. Corbett. Ernest R. Springer, chief engineer, is directing the work, and W. W. Davis, his assistant, is in charge of field engineering.

Engineering and Mining Journal.

Group of graduates of the Colorado School of Mines with A. D. Walker, resident manager of the Engineer's Lease, Inc.

Alumni Leases Aid Engineers

TO HELP tide its unemployed graduates over the depression period and to enable them to gain valuable experience, the Colorado School of Mines Alumni Association has turned lessor of ground in gold mines at Cripple Creek, Colo. The association organized Engineer's Lease, Inc., under the Colorado laws with a capitalization of 5,000 shares of $10 par value stock. It then appealed to alumni of the school in all parts of the world to subscribe to stock. A prospectus giving full details of the intended activities was issued. Five members of the association serve as directors of the leasing unit.

A lease was obtained last autumn on a block of ground 300x450 feet and extending between the 700- and the 900-foot levels of the Vindicator Mine, one of the famous old producers of Cripple Creek. It was taken on the so-called split-check basis which has prevailed in the district for many years. This agreement provides that the owning company shall furnish equipment, compressed air, powder, and other supplies, while the lessor furnishes the labor, engineering, and management. Net returns are divided equally between lessee and lessor.

Alumni desiring work are employed at a wage of $1.25 a day, which is sufficient to pay for board, lodging, and working clothes. Including insurance, the labor charge amounts to about $52 per month per man. Every three months a settlement is made. Profits are distributed on the basis of two-fifths to Engineer's Lease, Inc., two-fifths to the men engaged in the work, and one-fifth to the alumni association. A. D. Walker, who since his graduation from the school in 1912 has followed mining in the district, is resident manager. He determines the capabilities of the men and allots them work accordingly. C. Lorimer Colburn, secretary of the alumni association, serves as general manager.

The plan is a modern variation of the time-honored grub-stake system. The number of men that can be given employment will depend upon the response of alumni in buying stock. During the first three months of operations more than $5,000 was subscribed, and as many as twenty graduates were given employment. If the venture proves profitable, the stockholders will, of course, share in the returns through dividends.

Leases were taken on the Cresson and the Portland mines as money became available to put additional men to work. It is understood that the Portland lease has been given up because it did not appear sufficiently promising of results. The Cripple Creek ore is a free-milling telluride; and facilities for treatment at low charges are available at the Golden Cycle Mill in Colorado Springs.

Publicity given the venture has brought appeals from other schools to place some of their unemployed graduates, but thus far sufficient funds have not been forthcoming to take care of all the applicants from among the Colorado institution's own alumni. Details of the plan have been supplied to various technical colleges, however, and several are said to be considering the formation of similar leasing groups.

Ewing Galloway

Bush Terminal a Crossroads of Commerce

Vision and Courage Have Created a Unique and Splendid Plant for the Promotion of Foreign and Domestic Commerce

R. G. SKERRETT

SOUTH Brooklyn and Bush Terminal are inseparably associated in the minds of those familiar with the amazing transformation that has been wrought in three decades in that section of the waterfront of the Port of New York. Indeed, the development of that part of the harbor might have been delayed for years had not the Bush Terminal been started there and expanded in the face of many self-evident drawbacks. For a goodly while there were many reasons for dubbing the terminal "Bush's Folly".

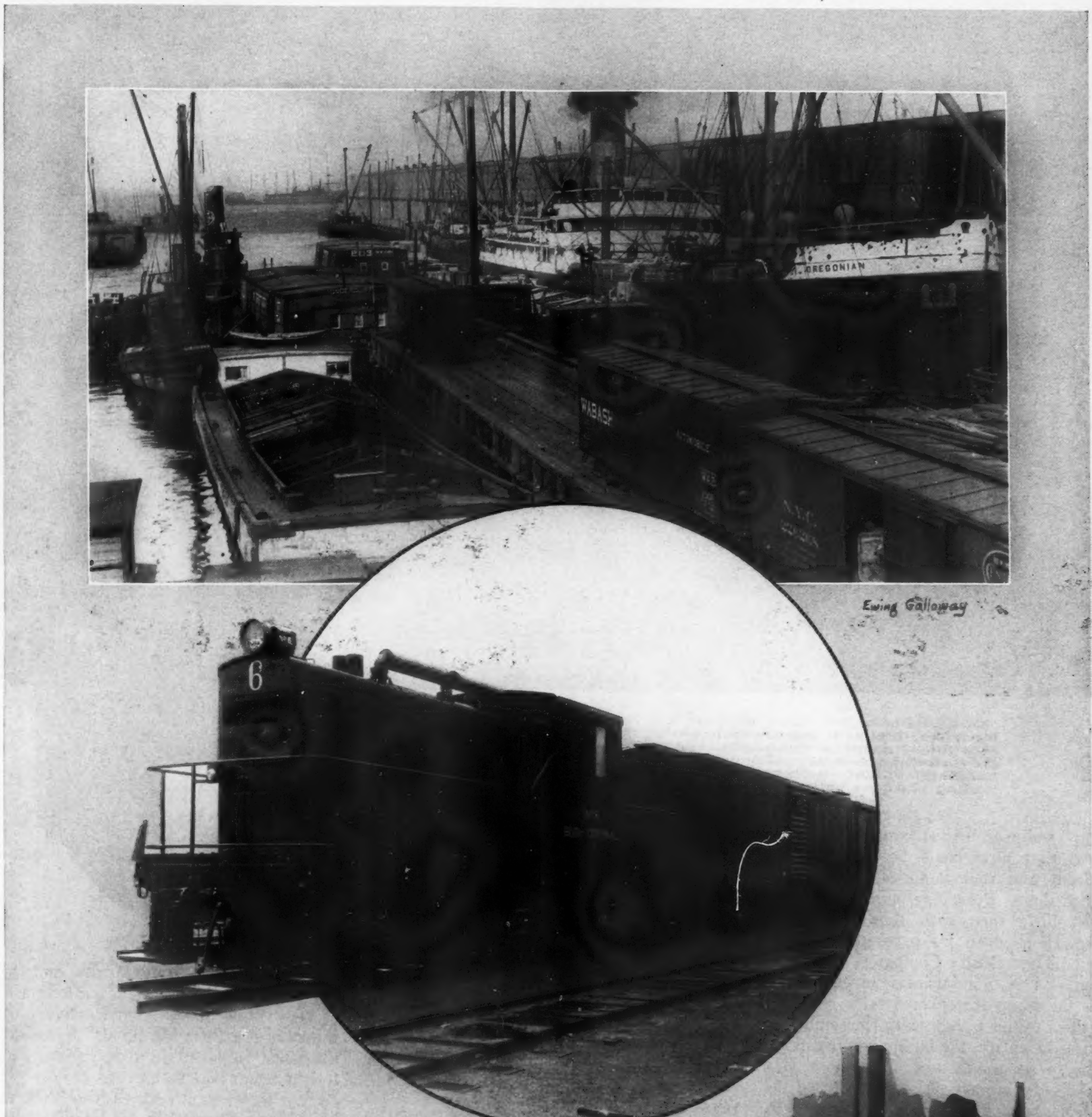
The Bush Terminal, as it stands today, is a monument to the undiminished energies of the man who conceived it and brought it to its present splendid proportions. Irving T. Bush has had and still has the spirit of the pioneer. Even after battling for years to make his youthful dream come true he is still forging onward undauntedly. More than once in his resolute climb to business eminence, Irving Bush has had to lift himself by his own boot straps over the barriers that beset his path—boot straps, in his case, being synonymous with resourcefulness and the will to achieve. Today, Mr. Bush is threescore years of age, and still planning things to do. Hard knocks have not quenched the flame of his inherent optimism. Only a short while back he made this declaration:

"I meet so many who proclaim that the human race is decaying, that youth is hopeless, and that civilization falters. I do not believe anything of the sort—certainly not so far as the United States of America is concerned—and I am weary of pessimists.

"Nations are like forests. Trees grow old and decay. Some are uprooted by tempests, and great sections may be laid waste by fire. Young trees push their heads through the soil, and new forests take the place of old—not always in the same place, for devastation is sometimes permanent, but the sun shines in the heavens, and God's rains nourish. Somewhere there is always new growth". New growth is symbolical of the Bush Terminal; and so, too, are increased capacity and readiness to meet changing conditions.

Because many thousands of our readers do not know the part that the Bush Terminal has played and is playing in promoting the business and the industrial welfare of numerous persons and interests, we shall sketch the origin and the development of this unique undertaking which, even though imitated in varying degrees, still stands preëminent in its particular field of service. This story of achievement exemplifies what faith in one's plans and the courage to stick to them aggressively can make possible. Had Irving Bush faltered in the days when the odds were heaviest against him, the Bush Terminal would have died in its early years. Having embarked upon this venture, young Bush held to his chosen course. When maturer heads cautioned otherwise; when his directors balked in the early days of the project; and when bankers generally rebuffed him, Irving Bush squared his shoulders and went ahead. In some manner, in each grave situation, he was able to steer a way to open water and beyond the reefs and shoals that beset him.

In 1890, Irving T. Bush came of age, and then inherited, among other things, 200 sand lots along the shore front of Brooklyn. The site, although only a mile away from the lower tip of Manhattan, might have been leagues distant so far as industry was concerned. Means of travel to and from New York and that section of Brooklyn were woefully inadequate for an enterprise that bid for water-borne traffic and for the business of shippers located anywhere and everywhere within the broad expanse of the nation. At



Top—Busy dock scene at Bush Terminal, which attracts to it vessels from every quarter of the globe. Circle—One of the seven Ingersoll-Rand oil-electric locomotives used for switching work in the freight yard. Bottom—Electric trucks are used to handle freight between the railway sidings and the warehouses.

Bush Terminal as it appears from aloft. The piers are adjacent to commodious warehouses, and in the middle distance are the railway freight yard and the numerous large industrial buildings. Right—Railway sidings with covered central loading platform between two adjacent industrial buildings.

the start, well-nigh no one except Irving Bush believed that piers could be built on that waterfront and that factories could be established there. Prevailing opinion, however, counted little then with that imaginative youth. He pledged his patrimony and organized The Bush Company, Ltd.—his mother and a non-business brother completing the group of stockholders.

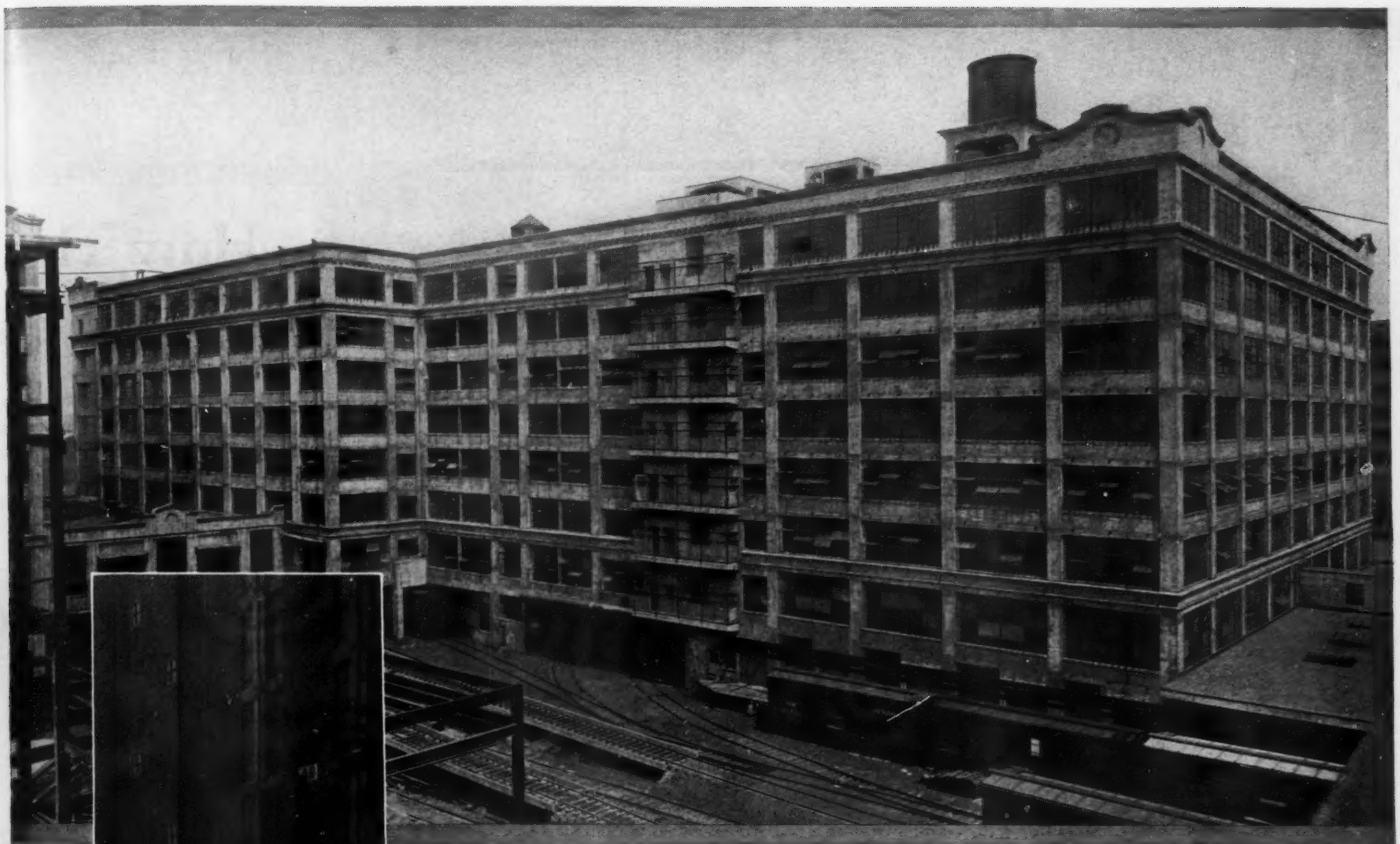
Fortified in this fashion with the semblance of business identity, the family trio began the erection of six warehouses, little more than copies of older storage places that dotted the Brooklyn shore at more favorable points. And then, to give a further appearance of readiness for business, the company built out from the adjacent waterfront a 350-foot section of the first projected pier. The remainder of that structure was not taken in hand until considerably later. While the walls of the warehouses were rising, Mr. Bush bought secondhand a switching engine that had about reached its limits of usefulness in the service of the none-too-prosperous Erie Railroad. That trunk line was not then what it has since become. Next, an aged tug and a well-worn car float were added to the plant property; and thus equipped The Bush Company, Ltd., deemed itself prepared to compete with other concerns in the handling of freight in the Port of New York. Disillusionment came promptly!

Somehow none of the railroads having terminals in the Port of New York could see their way clear to turn over freight to the Bush Company as they did to other private terminals in the harbor. Repeated visits to the offices of railroad officials and the exercise of all his persuasiveness were unproductive. There was inevitably some higher authority who must be deferred to, and as far as Irving Bush was concerned that exalted being was a sphinx, because the outcome remained an enigma. Furthermore, the railroads refused to quote rates to and from the Bush enterprise. Mr. Bush thus describes how he then determined to deal with the impasse.

"I went back to South Brooklyn and looked over my little express-wagon equipment of one locomotive, one car float, one towboat, and no job. I decided that the only way to secure the interest of the railroads was to give a practical demonstration that there was freight to be moved. The theory seemed to be all right, but how was I to secure the freight........I looked at my bank balance, which was small and shrinking. I tried to think of the cheapest thing I could buy that would look big and that I could sell, perhaps at a profit."

Just at that critical moment, Mr. Bush saw some of his horses at their noonday meal of hay and oats; and then the idea of how to meet the situation occurred to him. He could send someone out to his old home in Michigan where he could buy hay directly from the farmers. His agent was authorized to buy enough baled hay to fill 25 cars, and then to approach the nearby freight station for a rate to New York that provided delivery on the tracks of the Bush Terminal. A carload was the usual shipment in that region; and the freight agent was so aroused by the offer of 25 that he wired at once to New York for instructions. The railroad bit at the bait; a rate was given, and the Bush Terminal was placed then and there on the transportation map for keeps! Strategy prevailed where appeal had been futile.

The hay reached the Bush Terminal over several deliberately selected routes—each one adding emphasis to the existence of the terminal; and that fodder was disposed of at a small profit in due season. But the Bush Company was not so circumstanced financially that it could go afield and buy commodities to furnish freight for its own handling. It was indispensable that freight from other sources should be directed or diverted to the terminal for storage or for redistribution. It was at this point that another great truth concerning service was borne home to the young manager. As he has expressed it: "I learned that the service must not only be es-



Close-up of one of the score of reinforced-concrete industrial buildings within which activities of many kinds are carried on. Left—Hoisting stations are placed at intervals along the waterfront highway in the terminal, and each one is capable of serving several sections of a warehouse group.

tablished but maintained, whether it is used or not, if it is to be worthy of patronage. The world will not seek you out to demand that you perform a service until you have equipped yourself and are performing it and have let the world know that you are on the job."

This realization led to the purchase of some more secondhand car floats; and the old tug was supplemented by the hiring of other towboats. The motive power in the railway yard was amplified by the buying of a little steam locomotive that had worked on one of Manhattan's elevated lines. With this assemblage of floating equipment and locomotives, the terminal kept up scheduled runs between Brooklyn and the freight yards across the harbor and was in a position to do the necessary shifting of cars when they reached the Bush plant. Despite these facilities, freight for a long while arrived in small quantities while expenses mounted at a disquieting rate. Eventually the tide turned; but the struggle for commensurate recognition was a long, uphill one. In a normal year now, the Bush Terminal moves substantially 2,000,000 tons of rail freight.

With a single small pier available, the terminal was unable to induce ocean-going vessels to make use of it; and by way of a gesture to the world at large, Mr. Bush charted two old and small Norwegian tramp steamships and put them in service between Brooklyn and the West Indies. The experiment was all right so far as its fruitfulness in the matter of experience; but it netted a loss of $10,000 which Mr. Bush charged off as advertising. In the end the venture was good business, because it demonstrated that a steamship line could use the terminal; and the pioneer operation of the tramps served to draw to it seagoing craft that paid handsomely for the accommodations placed at their disposal.

Much as we should like to present all the high points of the evolution of the Bush Terminal and the resourceful way Mr. Bush has dealt with each arising difficulty, space is too limited for us to do so. One of the great problems was that of neutralizing its isolation by promoting regular and frequent ferry service between the vicinity of the terminal and the southern shore of Manhattan. This was indispensable, because freight had to be trucked from shore to shore, and conveniences had to be provided for persons doing business with the terminal or for the carriage of passengers arriving or departing by steamers using the terminal. All these drawbacks have been disposed of, but not always easily.

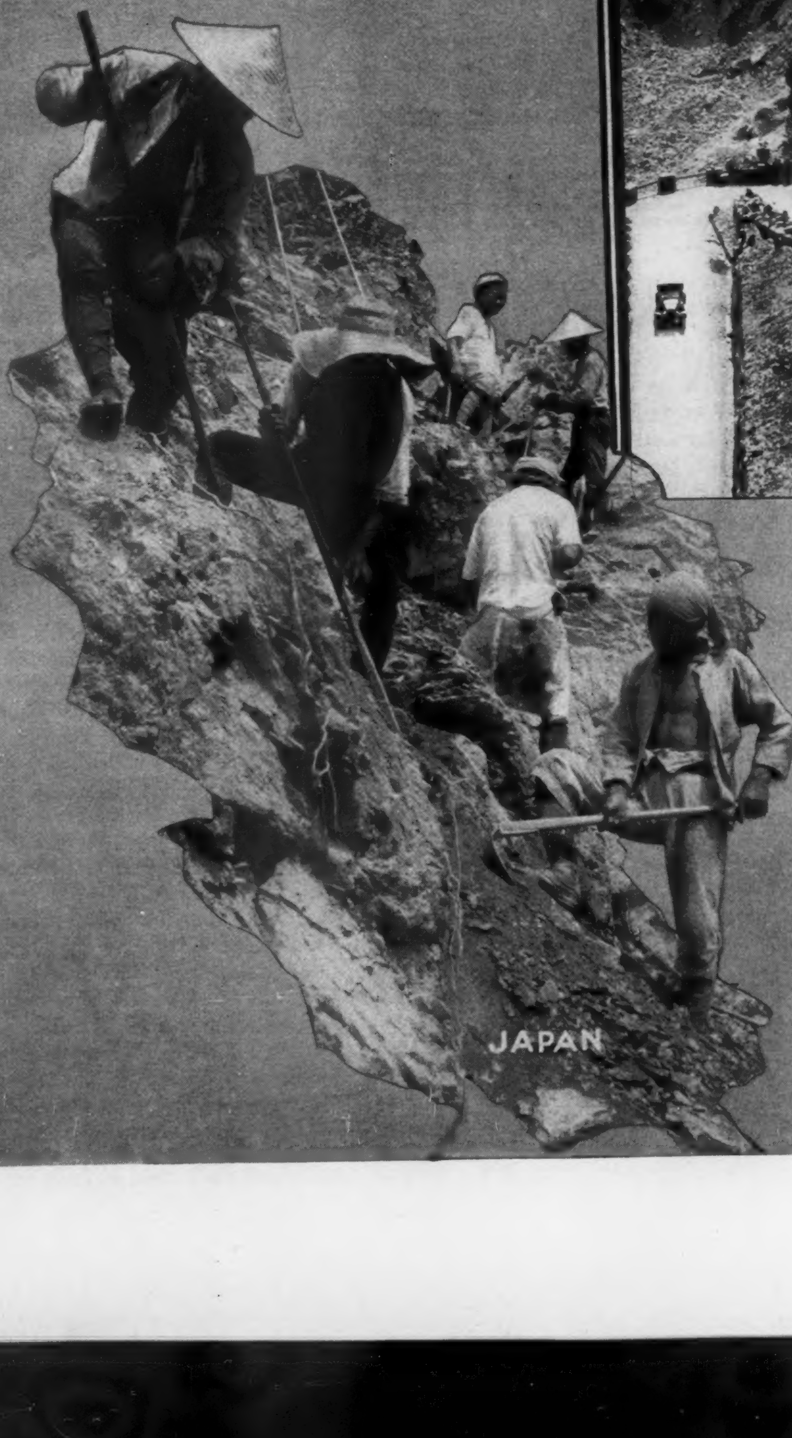
Those unfamiliar with the Bush Terminal will ask: Wherein does it differ from terminals generally, and why should it have been called into being? We shall let its originator answer these questions. "I had hoped to erect a series of modern factory buildings which could be leased to business concerns very much as apartments were rented for family occupation. The underlying thought was that every manufacturer would like to have at his command a modern factory building equipped with every device to make its use economical. He would like such a building located in a good labor market, and served by all the railroads. He would like to have at his command, when needed, a trucking and lighterage service that would carry his merchandise to every part of the city and harbor. It was only possible for very large concerns of great wealth, doing an enormous business, to afford for their individual use such a group of facilities. My plan was to offer, to a group of many smaller enterprises, facilities that would put them upon an equality with their larger competitors." For the sake of clarity it should be mentioned that The Bush Company, Ltd., ceased to be, and that the Bush Terminal Company came into being in 1902—about eight years after the original organization had essayed to turn the unpromising sand lots into the site of something radically new in business undertakings.

Today the Bush Terminal numbers manufacturers and sales organizations of widely differing sizes among its 300 and more tenants. Some of these are listed among the largest,

(*Continued on page 3801*)

How the World Its loads

TO those of us that have be d to believ ly a machine age, some the scenes prove enlightening. The pl zation of may be contrasted with the stration i shows a modern portable ai mpressor speedily drill rock on an Ame n mountai



World Builds
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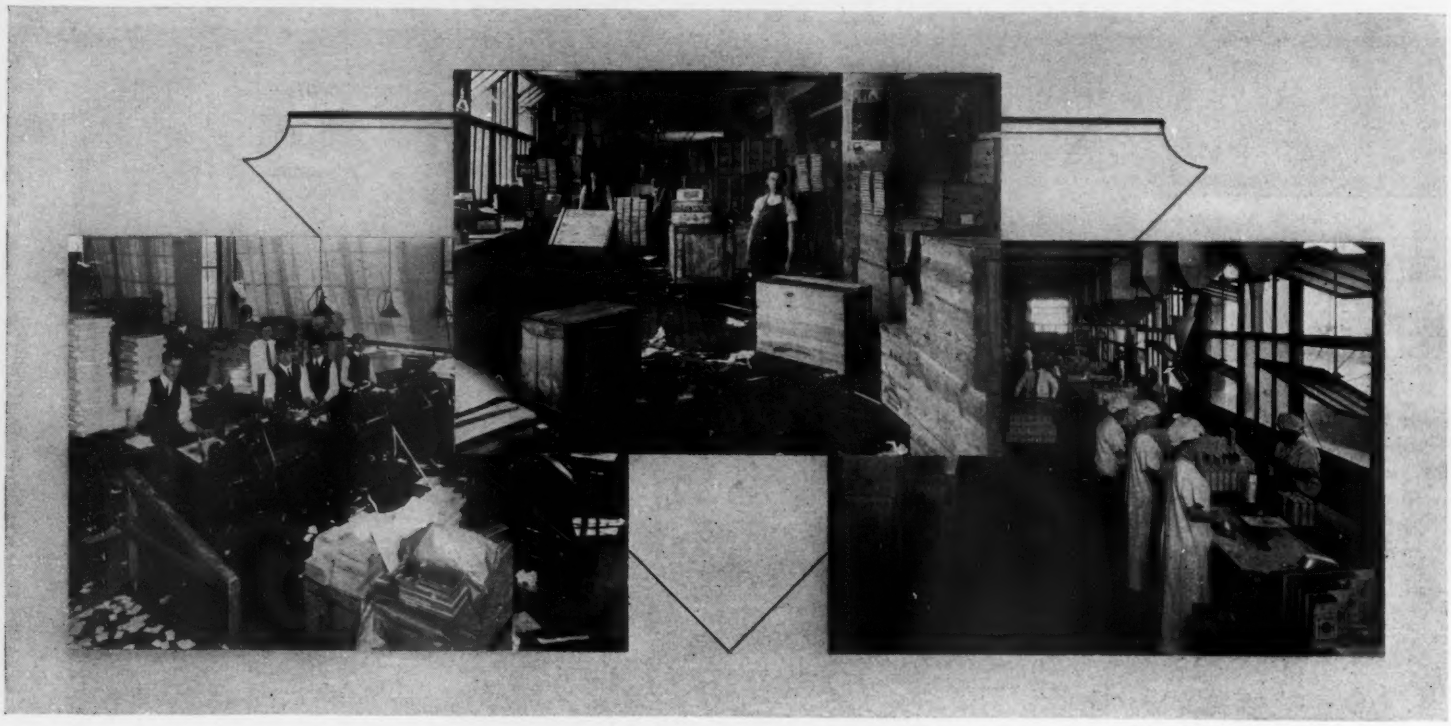
INDIA

Photos, Ewing Galloway, New York



Some of the many and varied activities pursued in the industrial buildings. Top—A redistributing department maintained at the Bush Terminal by a distant manufacturer. Left—A printing plant finds the terminal a convenient place in which to do business. Right—Putting up in package form a well-known commodity for household use.

the most elaborately organized, and the most efficient corporations in the United States. They have found in the Bush Terminal an aggregation of conveniences that is not to be had elsewhere for the same money; and with these economies they obtain operating aids that permit substantial savings in that very important department of modern business—that is, distribution. The man with small space has at his command precisely the same service and the same facilities that are enjoyed by the large user.

Distribution, at least so far as it concerns the producer of commodities, is a physical act, and consists in the moving of an object from one point to another. Efficient distribution means doing this very thing with dispatch, with the least amount of handling, and with a minimum of lost motion. Distribution in this sense is one of the cardinal principles governing the management of the Bush Terminal. In successful manufacturing and marketing, production and distribution are interdependent; and distribution should be of that order that will permit the movement of commodities from their sources to their markets in large or small volumes in accordance with the varying demands of consumers. This may mean warehousing at points of redistribution; and it is in this class of service that the Bush Terminal also offers outstanding advantages. Indeed, in several instances the terminal has saved the day for remote producers and has made it possible for them to do a profitable business in the Metropolis notwithstanding keen local competition.

Nothing short of a visit to the Bush Terminal would serve to make clear the extremely diversified nature of the plant's activities; and in lieu of this we shall have to resort to an abridged description of this veritable beehive of varied and intensified efforts. The plant is distributed over 200 acres either on or adjacent to the waterfront; and jutting out from the shore are eight piers that have an aggregate of 2,000,000 square feet of floor space. One of these is 1,250 feet long and 272 feet wide—the largest double-deck covered freight pier in the world. The wharves will berth as many as 35 vessels at a time, and are leased by companies operating 26 steamship lines that serve some 85 ports scattered far and wide throughout the maritime world. While the City of New York has a shore line of nearly 600 miles developed to deal with ocean-going traffic, still the Bush Terminal handles fully 20 per cent of all the export and import business of the port.

The Bush Terminal has railway facilities that include an ample number of locomotives and about 35 miles of track arranged to accommodate 1,000 cars. In the course of a normal year 110,000 cars are handled. By means of car floats, owned and operated by the Bush Terminal Company, this railway system connects with all the trunk-line roads that touch the Port of New York. A union freight station for the reception and the delivery of freight moving by any of the trunk lines is available to all shippers and receivers, irrespective of their locations. As an integral and essential part of the terminal there is a cold-storage plant with a capacity of 1,000,000 cubic feet. Commodities of all sorts and kinds are stored there for a longer or shorter period, depending upon their nature and requirements. An up-to-date fumigating and sterilizing plant has also been built for the treatment of vegetables, fruits, and the like from abroad that must be so processed before their distribution throughout the country is permitted by the Government.

In addition to the foregoing facilities there are 125 warehouses for general storage purposes with a combined space of 26,000,000 cubic feet. Next, there are no fewer than eighteen model industrial loft buildings that provide 6,000,000 square feet of floor space for use by tenant manufacturers, assemblers, or distributors. These buildings are of reinforced concrete—80 per cent of their outer walls being window area to insure an abundance of natural light and favorable working conditions. Every square foot of roof space is protected by a sprinkler system. Besides this the plant has its own organized fire-fighting force. Because of this, insurance rates at the Bush Terminal are notably low.

Electricity for light and power, and live steam for heat and power are furnished all users at reasonable rates. The loft buildings are provided with numerous passenger and freight elevators that are in the charge of carefully chosen operators; and intramural trucks are available for moving and stacking goods within those buildings. Spur tracks flank each loft structure; and cars can be loaded and unloaded at covered platforms. Cars bound to or from trunk lines are hauled over routes that avoid congestion; and often a day or more can thus be saved in transit.

For distribution within the metropolitan zone, the Bush Terminal maintains a numerous fleet of motor trucks; and these vehicles render it possible for a tenant to make deliveries quickly and at short notice. Time and time again sales have been effected because of this service—sales that otherwise would have been recorded under the disheartening heading of "Lost Business". We might go on indefinitely in an effort to enumerate what the Bush Terminal offers to cus-

Some of the up-to-date piers viewed from one of the warehouses flanking the main highway.

tomers or tenants, large and small; but we shall have to sum up the situation by saying that the company, with ample warrant, claims to be able to provide every facility for the promotion of business under exceptionally advantageous conditions to all concerned.

It should be self-evident that the movement of commodities within the Bush Terminal property is a vital aspect of the activities there; and, like in every other department of the vast undertaking, thoroughly up-to-date railway motive power is available. Heretofore, the switching and the spotting of cars has been done by steam, electric locomotives, and gasoline tractors. The steam and electric locomotives answered well enough for years for the heavier yard work; but in keeping with the policy of continual progress and the employment of the most efficient and economical means, the company has recently adopted oil-electric locomotives for switching service. Seven of these units have been purchased; and they are of the well-known Ingersoll-Rand type.

Each locomotive is of 55 tons; and the primary source of power is a 325-b.hp. Ingersoll-Rand diesel engine. The heavy-oil engine drives a General Electric generator; and the current so produced is distributed to four traction motors mounted directly on the axles. The motors drive through single-reduction gearing. These locomotives, with certain minor improvements, are virtually duplicates of Ingersoll-Rand units sold to a number of railroads and industrial concerns for similar duty; and it was because of the fine showing made by them elsewhere that the Bush Terminal decided in their favor. The seven oil-electrics are counted upon to do all the work previously done by twelve steam and electric locomotives. Operating economy was the fundamental reason for the change in railway motive power.

The oil-electric units have been in use in the Bush Terminal yard too short a time to furnish any figures that would be at all conclusive; but their purchase was the result of surveys made by Ingersoll-Rand Company. Those surveys embodied data obtained from the many other locomotives built and sold by the same organization—the figures representing what may reasonably be expected over a working period of a year. Without entering into details concerning the cost of fuel, lubrication, supplies, repairs, labor, etc., the oil-electric locomotive should show in Bush Terminal service an approximate saving of $1.05 per locomotive-hour compared with a gas-electric locomotive of the same power, and a saving of $2.15 per locomotive-hour when competing with the steam and electric units formerly in use. These figures should be persuasive to any plant management that has work of the same sort to do and that is also intent upon cutting operating costs.

In December of 1927 a bronze tablet was erected in the Bush Terminal commemorative of the twenty-fifth anniversary of the acquisition of the properties upon which it stands today. In accepting the tablet on behalf of the Bush Terminal Company, Mr. Bush concluded his speech in this manner: "When you pass this tablet in days to come, do not think of it as a tribute to me. Think of it as a token of your pledge and mine to give the world something worthy of our opportunity, and to leave behind us something better than we found. That is the Spirit of America. Let us be humbly proud of our share in it." So spoke the "practical idealist", as the late Thomas A. Edison classed Mr. Bush, and as the latter likes to be considered.

When the tide of business is at its flood, the Bush Terminal draws to it daily a working personnel of quite 30,000—such being the demand of the plant's multiple departments and the needs of the industries quartered within its gates. Not all the enterprises can find work the year round for all their people, and many of them are somewhat seasonal in their maximum outputs. However, because of the close association of the industries, when operation slackens in one it is apt to pick up in some other, and thus something is found for most everybody to do month in and month out.

When the Bush Terminal Company absorbed The Bush Company, Ltd., the associated properties were assessed at $3,450,000. Today, the assessed valuation is close to $40,000,000! So much lies behind this achievement: success did not come without a hard struggle. Mr. Bush says: "There were days when I did not know where money for absolutely necessary improvements was coming from, or how payrolls were to be met, but, through it all, the Bush Terminal managed to pay its own way......It has been a development built upon the theory that progress in industry is not made by scientific development alone but by making one move take the place of two, of eliminating unnecessary effort and useless cost. Efficiency is built upon that cornerstone, and efficiency is one of the foundations of American success."

Architecturally beautiful Bush House in London is the European center of operations of the Bush Terminal Company.

Human beings become pygmies in such a setting.

Lower end of the workings and the network of roads for disposal of the tunnel spoils.

Muck truck with protective hood over the driver.

Looking out of the gaping maw of one of the huge diversion tunnels.

Construction of the Hoover Dam

Details of the Driving of the Four Huge Tunnels which will Divert the Colorado River Around the Dam Site

NORMAN S. GALLISON*

THE first major operation confronting Six Companies Incorporated in the building of the Hoover Dam was the driving of four great tunnels through solid rock. These will carry the Colorado River around the dam site while excavation for the dam foundation is underway, and thereafter until the massive concrete barrier has been partially erected. There are two of these diversion bores on each side of the river. As driven, they are circular in cross section and 56 feet in diameter. After being lined with 3 feet of concrete, they will have a finished section of 50 feet. Their combined length is 15,909 feet, and their individual lengths are: No. 1—4,300 feet; No. 2—3,879 feet; No. 3—3,560 feet; and No. 4—4,170 feet.

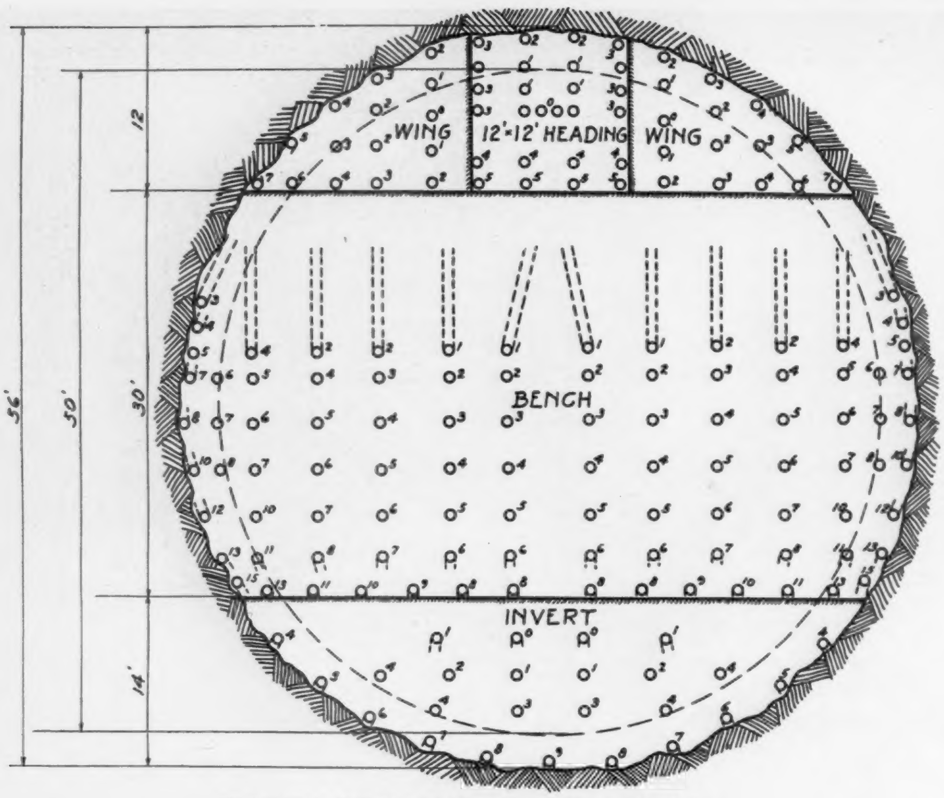
At the dam site, the river flows through a narrow box canyon whose walls rise sheer from the water's edge to a height of 800 to 1,000 feet. The tunnels enter these precipitous cliffs about 2,000 feet upstream from the axis of the dam site, follow roughly semi-circular courses through the walls, and emerge approximately 2,000 feet downstream from the dam site. The beds of these passageways are a few feet lower than the normal river level. From intake to outlet, each bore has a fall of about 14 feet. The intake portals of the two tunnels on each side of the river are relatively close together but, owing to the conformation of the canyon walls, they are not truly parallel and are farther apart at their outlets.

After these tunnels have served their primary purpose of diverting the river's flow, they will not be abandoned. The two nearer the river will be closed off with concrete plugs, above and below the dam. In the lower plugs will be installed needle valves, which will serve, through the penstock pipes, as outlets for regulating the flow of the river below the dam while the reservoir is filling to the elevation of the intake towers. These tunnels will also house the pressure penstocks from the intake towers for a portion of their length. The outside set of tunnels will be bulkheaded at the upper portals and about midway in their courses, from which latter points steeply inclined tunnels driven to the surface will, when equipped with suitable structures at their tops, act as spillways for the overflow waters.

The driving of the four tunnels involves the excavating of nearly 1,500,000 cubic yards of rock within the tunnel lines. A further vast amount of material was removed in gaining access to the various points of work. Operations were started in May, 1931, and at the present time it seems reasonably certain that they will be completed during the present month, so that the total elapsed time required will have been about a year. This is considerably under the best estimates made prior to the beginning of work. Operations have been carried on 24 hours a day, in three 8-hour shifts. As many as 1,500 men have been engaged in the tunneling activities, and the average number employed has been 1,200.

*Public and Press Relations Division, Six Companies Incorporated.

Seventh of a series of articles on the Colorado River and the building of the Hoover Dam.



Holes were located as shown above and fired in the various sections in the order indicated.

As soon as they took hold of their contract, Six Companies made preparations to begin tunnel driving, with the result that drills were biting away at the rock several weeks before a roadway had been constructed into the bottom of the canyon. About two miles above the dam site, the canyon broadens out into the reservoir area. There, at the foot of Hemenway Wash, access to the river level by trucks could be had over a rough desert road. Barges were constructed at this point; Ingersoll-Rand Type 20 and Type XL portable air compressors and drilling tools were loaded aboard; and the first expedition set forth. The only spot in the canyon proper where a foothold could be obtained was on the Arizona side of the river, near the center of the future dam. At this point was a small talus slope formed by rocks which had fallen from the cliffs above. Workmen on the barge, which was lowered downstream by cable, were able to moor their craft and unload compressors, a portable blacksmith shop, drills, and other equipment among the rocks.

The plan of attack adopted by Six Companies Incorporated was to drive adits into the canyon walls on either side of the river to intersect the lines of the diversion tunnels midway between portals. The first hole was drilled for the Arizona adit on May 12, 1931. Ingersoll-Rand Type N-75 drifter drills and Type S-49 "Jackhamers" were used. The muck was hand shoveled into 1-cubic-yard mine dump cars and deposited along the canyon wall to enlarge the bench for further buildings. A cable suspension footbridge was then thrown across the river to gain access to the Nevada side. There a shelf was blasted from the cliff, and operations were begun in the same manner as on the opposite shore. These adits were driven 10x8 feet in cross section. The Arizona entry was 850 feet long, and that on the Nevada side 630 feet long.

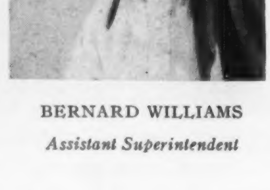
Electric power was available on June 25, 1931. Prior to that time two Ingersoll-Rand Type XRE stationary compressors, each with a 1,302-cubic-foot piston displacement, were installed and connected to two 200-hp. Atlas diesel engines. These units furnished air for driving railroad tunnels and for roadbuilding. When power lines had been strung, the machines were converted to electric drive. About the same time a compressor plant near the Arizona adit was placed in operation, and this supplied air at 105 pounds pressure through 4-inch lines to the adit drilling crews. The plant consisted of two Ingersoll-Rand Class PRE units, each of 2,195 cubic feet per minute piston displacement. Later another compressor station was established near the lower portals of the tunnels on the Nevada side. It contained four Type XRE and two Class PRE machines having a combined piston displacement of 9,598 cubic feet per minute. All three of these compressor plants were interconnected by 6-inch lines; and air was distributed to the various points of use through a system of 4- and 6-inch mains having an aggregate length of some 30,000 linear feet.

Ten-ton Baldwin-Westinghouse storage-battery locomotives and 3½-cubic-yard Western dump cars were brought in by barge and used to haul muck. When the lines of the diversion tunnels were reached, 12x12-foot top headings were opened off the adits in both directions. The purpose of driving the top headings in the main bores was twofold: to provide ventilation and convenient access for the enlarging operations which were to follow, and to furnish accurate information as to the character of the rock to be encountered throughout the length of the tunnels. By driving the adits, eight faces were opened up for attack in addition to those at the portals. Actually, the bulk of the footage in the top headings was driven through the adits. As soon as access could be had by cutting a road down the steep canyon walls, top headings were opened up at the lower portals of the two tunnels nearer the river and driven upstream toward the adits.

When electric power became available, top headings were drilled from a rig consisting of two horizontal bars or vertical columns mounted on a drill carriage running on the narrow-gauge rails used for mucking. Thirty-two holes, 10 feet deep, were drilled to a round, and the average depth broken per round was 8.3 feet. Mucking was done by Conway mucking machines. Crews working from the adits alternated as to headings, drilling one face while mucking operations were underway at the other. Although sixteen possible faces were available, actual conditions prevailing on the job were such that twelve faces was the most ever worked at one time. Progress in the top headings by months was as follows:

June	410 ft.	October	4,147 ft.
July	1,045 ft.	November	3,025 ft.
August	1,439 ft.	December	1,191 ft.
September	3,235 ft.	January	120 ft.

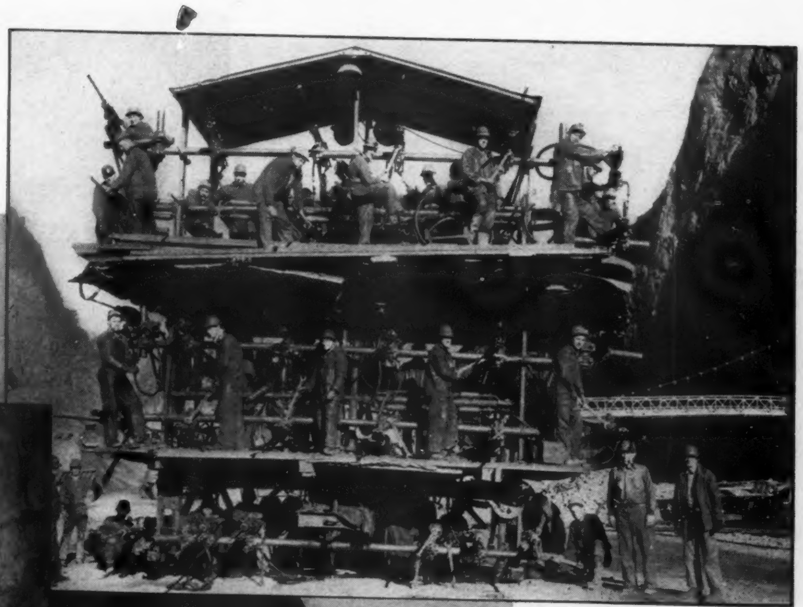
It will be noted that the total of 14,612 feet does not correspond with the combined length of the diversion tunnels. This discrepancy is due to the fact that the main bench operations were started on several of the portals before the top headings were completely driven through from the adits. Rock excavated from the top headings totaled 79,000 cubic yards. Much of this muck was dumped along the canyon walls to form roadways from the adits to the lower portals.



BERNARD WILLIAMS

Assistant Superintendent

In gaining access to the lower portals of the diversion tunnels for the enlarging operations, considerable open-cut excavating, as well as scaling down of the canyon walls, was involved. The lower portal of Tunnel No. 4—the tunnel farthest from the river on the Arizona side—was the first prepared, and the initial round in the enlargement was fired on September 21, 1931. Since the top heading had not yet been holed through from the adit, a small 12-foot bench in the arch section of the tunnel was advanced one round, and then followed taking



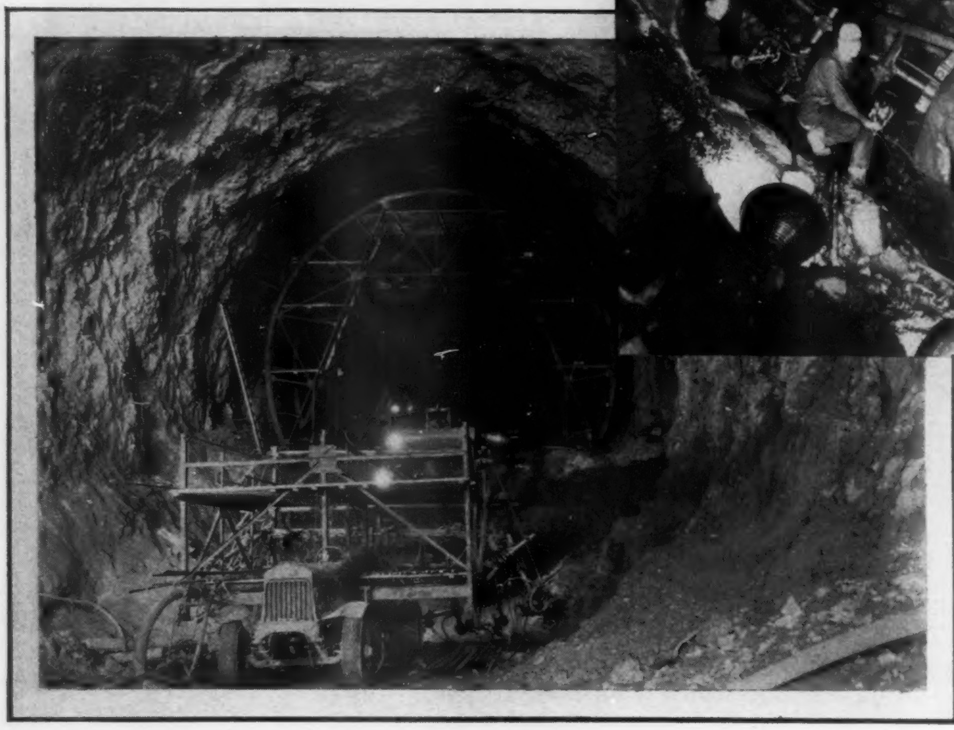
Above—Bench drill carriage and full crew.

Above—Drill carriage at work in tunnel.

Right — Lower tunnel portals during flash flood.

Drilling crew in 12x12 top heading.

The boom swings and 3½ cubic yards of muck is loaded.



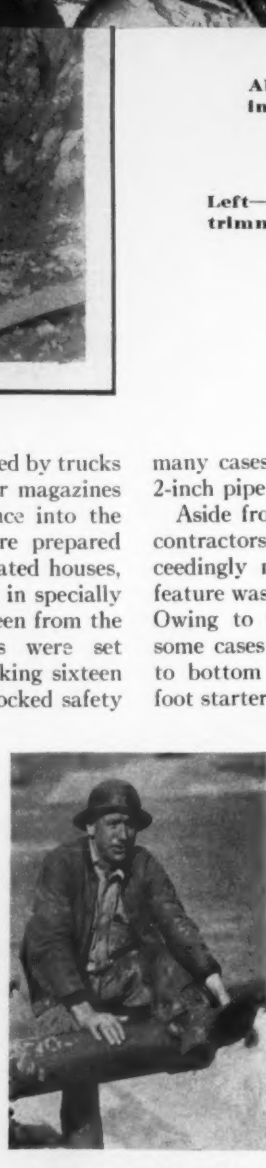
Above—Close-up of an invert drilling crew.

Left—Invert drill carriage and trimming jumbo behind it.

off a bench 30 feet in height. This latter stage in the enlarging operations was referred to by the contractors as the "bench heading", as distinguished from the top heading discussed previously and the invert section which was removed at a later operation. Upon its completion, the opening was approximately 42 feet in height and horseshoe shaped in cross section.

After a short period of experimenting, the method adopted by Six Companies Incorporated for driving the bench heading was by means of a drill carriage or jumbo mounted on a truck chassis. An experimental rig built of timbers was first constructed, and proved to be successful. Later, several rigs of welded steel were built in the company shops and mounted on International truck chassis of long wheel base. These drill carriages were equipped with five horizontal bars, with six Ingersoll-Rand Type N-75 drills mounted on each bar. A more complete description of these drill carriages was given in a previous article of this series. One-half of the main 30-foot bench was drilled with one setting of the carriage. The truck was then moved forward and backed into position on the other half of the face while the side previously drilled was being loaded. Meantime, the wing sections on either side of the top heading were being drilled from two vertical bars. Drilling of the wings was also carried on during the mucking operations on the main bench.

Forty per-cent gelatine dynamite was used throughout. The powder was hauled by trucks from central magazines to smaller magazines near the points of use, and thence into the tunnels as needed. Primers were prepared by powder-fitters, working in isolated houses, and were carried into the tunnels in specially designed containers. As can be seen from the accompanying diagram, primers were set from "no delay" up to "15", making sixteen delays. A 440-volt circuit, with locked safety switches outside the tunnels, was used for detonating. Careful attention to wiring the leg wires to the buses resulted in remarkably few missed holes. The finally adopted method of placing the holes in the various stages of drilling, and the firing sequence, are shown in an accompanying diagram.

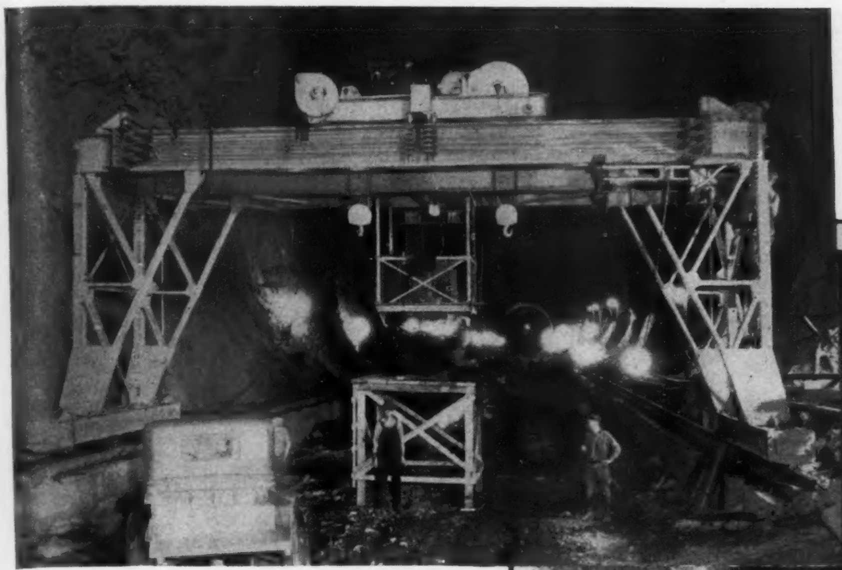


FLOYD HUNTINGTON
Tunnel Superintendent

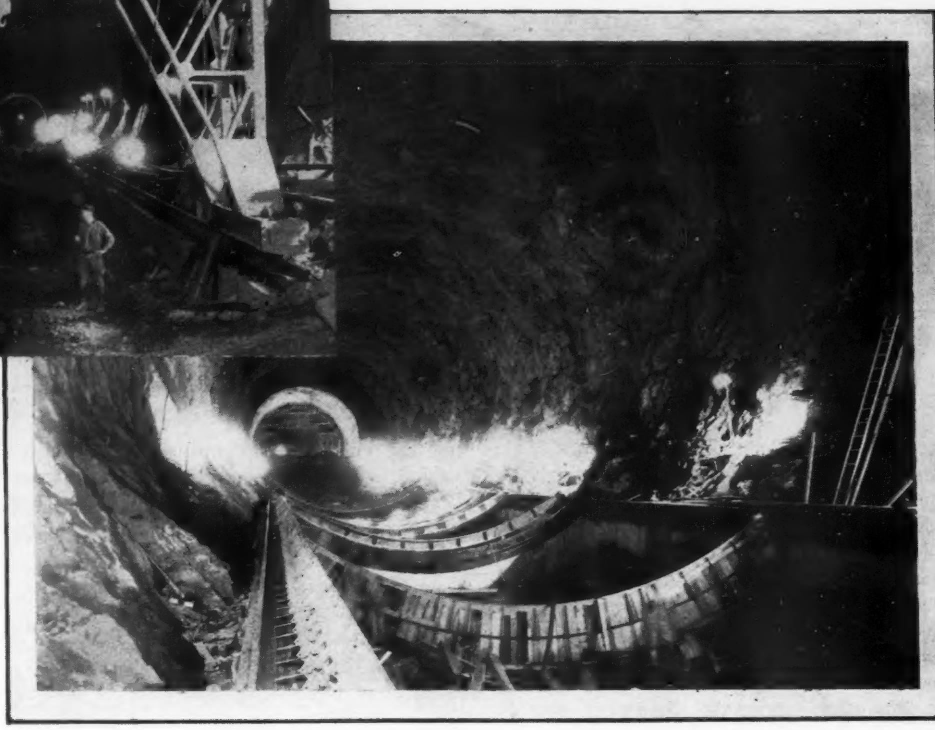
Electricity at several different voltages was required in the tunnels. The shovels used power at 2,300 volts. A 440-volt circuit was provided for blasting, and a separate lighting circuit of 120-volts was maintained. The tunnels were lighted throughout by reflectors hung along the walls up to within a few hundred feet of the face. Additional lighting was provided at the various faces by portable reflectors of 1,500-watt capacity. Water was pumped for use in drilling—in many cases directly from the river—through 2-inch pipe laid on the tunnel floor.

Aside from the ingenuity displayed by the contractors in the development of the exceedingly mobile drilling rig, an interesting feature was the length of steel used in drilling. Owing to the break of the rock, which in some cases left a pronounced slope from top to bottom of the main bench, 10- and 12-foot starters in the top holes were often necessary. The crews became exceedingly skillful in the handling of these lengths of steel, and also in their other operations.

During December and January, when eight faces in the bench headings were being worked, ten Ingersoll-Rand drill-steel sharpeners were in service. Shops were operated continuously in three shifts, and 30 tool sharpeners and 30 helpers were employed. These shops also cared for miscellaneous sharpening, in connection with the scaling of the canyon walls, railroad-bench and open-cut excavation, and other outside work. It is interesting to note that 23-foot steel was used on the drilling jumbos on the bench and invert headings. This accounts, in a large measure, for the excellent footage made per round. It required 97 tons of steel to equip



Above—Gantry crane used for pouring invert concrete.

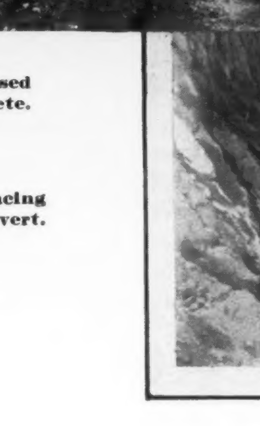


Right—Forms ready for placing the concrete lining in invert.

all the jumbos during this period. Each jumbo, on entering the tunnels to commence drilling, carried 25 sets of steel, which weighed 5½ tons. Each set consisted of from six to nine pieces, depending on the length of the starters.

The steel was changed on an average after each round—the sharpened steel being brought forward to the jumbo on 1-ton trucks when needed. Hollow, round, 1¼-inch drill steel was used throughout the job; and it was estimated that the loss due to wear, sharpening, breakage, and other causes was .32 pound of steel per cubic yard of rock removed.

The average time required to back the jumbo to the face, jack it into position, attach the air, water, and electric lighting connections, and point the drills, was twenty minutes. The average drilling time on the bench heading was four hours, and the average footage per round was 16 feet. The best progress on any bench heading was made between February 1 and 8, 1932, in the upper heading of Tunnel No. 4, when 280 linear feet was driven in sixteen rounds—an average of 17.5 feet per round. The best record made in any 24-hour period on all bench excavating was 256 linear feet in eight headings on January 20, 1932. The best individual record for one heading was 46 feet.



PAUL GUINN
Assistant Tunnel Superintendent

Mucking was carried on in the enlarging operations by Marion Type 490 one-hundred-ton electric shovels loading directly into dump trucks. These shovels came onto the job equipped with 2¼-cubic-yard rock dippers; but after some experimenting a 3½-cubic-yard dipper was installed by the contractors. Eight of these shovels were employed, one for each heading. Five drilling jumbos were in use, four of which alternated between two headings, with one in reserve. The work was so divided that one set of dump trucks served two headings in the lower portals, with approximately 25 trucks on each side of the river. At the upper portals, about 50 trucks of larger capacity were in use, serving all four portals as mucking operations required. The trucks were equipped with specially designed rock bodies, as can be seen in the accompanying illustrations. They were of various makes and types with capacities of from 7 to 14 cubic yards.

The muck was at first removed by hand from the small bench, which was carried one round ahead of the main bench. Because of the necessary length of the bench, this operation was tedious. A caterpillar 30 tractor, equipped with a bulldozer, was later installed in the top headings, and muck from the bench was pushed off and removed by the shovel from below. Mucking operations at the main bench were facilitated by the use of caterpillar tractors equipped with a bulldozer in front and a cowdozer in the rear. After a shot was fired, the bulldozer concentrated scattered muck at the base of the muck pile. Several times during the mucking operations the bulldozer was called into use to bunch the muck for ease of handling by the shovel. The cowdozer was called into play to scrape the muck away from the bench and to keep the tunnel floor alignment true. This also facilitated the alignment of the drilling jumbo at the face of the heading.

During the firing, the shovels were moved a few hundred feet back from the face. These electric shovels made an excellent performance record throughout the operations, with remarkably few shutdowns for repairs. An average of 110 cubic yards per hour was maintained, and individual performances were as high as 200 cubic yards per hour. The average mucking time, after each round, was nine hours, and approximately 1,000 cubic yards was broken with each round. During January, 1932, as much as 16,000 cubic yards, solid measurement, was removed daily from the tunnels and hauled to spoil dumps.

The problem of the disposal of the vast amount of broken rock, or muck, was one of the most difficult faced by Six Companies

B. A. PETERS LEIGH CAIRNS PETE HANSON FRANK BRYANT

These four "master muck movers" served as traffic managers for blasted materials.

Incorporated. Under the specifications of the contract, no material could be dumped into the river. Disposal areas were designated in side canyons; and where these were not available the muck had to be hauled up the side of the canyon walls on roads cut from precipitous cliffs. Steep grades of necessity prevailed. The distance that muck was hauled at the lower portals was one-half to one mile. To reach one disposal area, a 380-foot truck tunnel was necessary. At the upper portals, muck was hauled in dump trucks for a part of the time and dumped directly into 30-cubic-yard side-dump railway cars and hauled upstream approximately two miles to be used in widening the railway grade into the canyon.

The rock encountered in driving the diversion tunnels has been characterized as ideal for these operations. It is volcanic in origin, and geologically determined andesite tuff breccia. The rock is easily drilled; and when properly loaded breaks so that it may be conveniently handled by shovels. The rock is referred to by mining men as "dead". It requires accurate placing of the holes, but breaks remarkably true. No major faults were encountered, and such small seams as developed were all closed. No heavy ground was met, and no spalling or air-slacking developed—the tunnels standing through their entire lengths without timber support of any description. No water was found in any of the top headings, and only a small amount during the excavation of the bench headings. Some seepages occurred during the excavation of the invert, especially near the portals, but these will be grouted off during the lining operations. Measurements taken after the comp'etion of the trimming and scaling operations disclosed that, despite the rapidity with which the tunnels were driven, the average overbreak in the 56-foot section was only 7 inches.

Owing to special conditions that developed where open-cut excavations were necessitated and scaling operations were required above the tunnel portals, the dates of starting the enlarging operations of the tunnels varied from September 21, 1931, to December 27, 1931. The following tabulation showing the rate of progress is extremely interesting:

	Footage Progress	Faces Worked	Cu. Yds. Excavated
September	60.5	1	4,313
October	625	3	42,887
November	1,809	6	122,455
December	3,848	8	255,866
January	6,773	8	447,018
February	1,958	5	83,028
March	1,330	2	87,780

On March 28, 1932, there remained to be driven 205 feet of bench heading out of a total of 15,909.28. The estimated total excavation from the four diversion tunnels is 1,451,369 cubic yards, there being 91.225 cubic yards per linear foot in an ideal section of the 56-foot bore, made up as follows: Top heading, 5.333 cubic yards; bench heading, 66.002 cubic yards; and invert, 19.890 cubic yards.

The first tunnel holed through on the bench excavation was No. 3, the one closer to the river on the Arizona side. This tunnel—3,560 feet long—is the shortest of the four; and the final shot was fired on January 30, 1932. A few days later, on February 3, Tunnel No. 2 on the Nevada side, 3,879 feet long, was holed through. Work was suspended on bench headings in the lower portal of Tunnel No. 4 on February 1, 1932; and then was started the remaining section of the invert arch necessary to complete the excavation from a horseshoe section to a complete circle. Immediately after the bench heading was finished, invert excavation was taken in hand on both upper and lower portals of Tunnels Nos. 2 and 3. The bench excavation was continued on the upper heading of Tunnel No. 4, which was holed through on March 3, 1932.

The final enlargement of the tunnels is being completed in two operations. While the invert section is being excavated, the trimming and scaling of the tunnel walls to remove the projecting rock is carried on. The removal of the invert section is a similar operation to that on the bench heading. The same drilling carriages with the top part removed and with two folding wings built on either side are used for this purpose. Drills are mounted on the wings, which form a bar, curved on a 28-foot radius, the whole of the invert section thus being drilled in one operation. During February, 1,993 linear feet of invert was removed, and in March, 5,692 feet. Six faces were worked, and 152,931 cubic yards of muck was removed out of an estimated total of 316,604 cubic yards.

TOM REGAN
Assistant Tunnel Superintendent

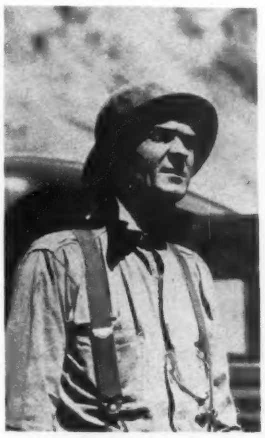
The operation of trimming or scaling rocks projecting within the clearances allowed is accomplished by a trimming jumbo, and is carried on coincidently with, and a short distance ahead of, the invert excavation. A horseshoe-shaped steel framework is erected in each tunnel. This framework has an outside diameter of 50 feet, and is mounted on wheels traveling on 90-pound rails laid true to line and grade. Platforms are erected at different elevations on the framework, and drills are mounted on bars at various points. The projections within the minimum allowable clearance are thus easily determined, and, when necessary, short holes are drilled and protruding points blasted on to

"SI" BOUSE, Master Mechanic *"MORT" LEDERER, Sup't Motive Equipment* *C. A. HARRIS, Chief Electrician*

Three important personages in the tunnel-driving organization.

the floor, where the muck is removed by the invert operation, which follows.

Ventilation was supplied in the adits and top headings by Roots blowers, discharging air through 18-inch pipes at the rate of 8,000 cubic feet per minute. During the driving of the main bench headings, a strong current of fresh air was drawn in through the 10x8-foot adits, forced through the 12x12-foot top headings, and discharged into the enlarged tunnels by pressure fans with a capacity of 35,000 to 120,000 cubic feet per minute—the air being introduced in the top of each tunnel, aiding the natural air currents from the portals.



C. T. HARGROVES
Assistant Tunnel Superintendent

Tests showed that there was a natural air movement of 1 to 2 feet per second from the portal toward the face in the bottom half of each large tunnel, and one of similar velocity in the opposite direction in the upper half. These natural currents were the result of a temperature difference between the atmosphere outside and the warm rock inside. A striking example was the relatively rapid up-draft always present at the face of a newly broken down muck pile.

The introduction of fresh air through the top headings accelerated the natural air currents and maintained a cool, clean, and pleasant working condition for the muckers. Tests showed that, under working conditions, activities could be resumed in five minutes after blasting with perfect safety and comfort; and the first truckload often went out fifteen minutes after the shot. Natural convection took the powder smoke to the vaulted roof and allowed men and equipment to move in under it. Then the accumulated gases were forced out by the combined action of natural and forced draft.

All the workings, involving truck operations, were thoroughly and periodically checked for air pollution. The degree of vitiation, particularly with relation to carbon-monoxide gas, was insignificant in comparison to that of vehicular tunnels, particularly where these have a definite sag, such as in the Holland tunnel.

During February, 1932, a flash flood in the Colorado River, amounting to approximately 50,000 cubic feet per second, topped the temporary embankments and flooded the tunnels. Damage was nominal; and work was suspended for several days while the tunnels were pumped out and the deposit of slime and silt was removed.

During the driving of the main bench headings, a crew of approximately 80 men was required in each heading. The crew on the drilling jumbo consisted of 22 miners, 21 chuck tenders, five nippers, one safety miner, and one drilling foreman or shifter. In addition, two crews of fifteen men each were engaged in drilling the wings on either side of the top heading. The mucking crew consisted of a shovel operator, an oiler, and a pitman. In addition to the foregoing, electricians, pumpmen, powdermen, and superintendents operated in more than one heading. The daily wages of the jumbo and mucking crews were as follows: miners, $5.60; chuck tenders and nippers, $5; shovel operators, $10; oilers and pitmen, $5.

JACK LAMEY
Assistant Tunnel Superintendent

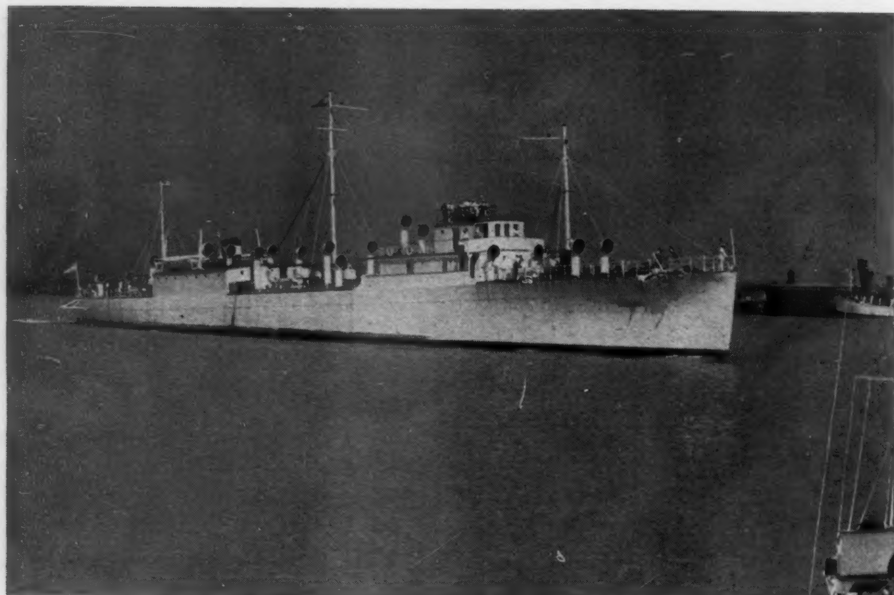
ALUMINUM SOLDER

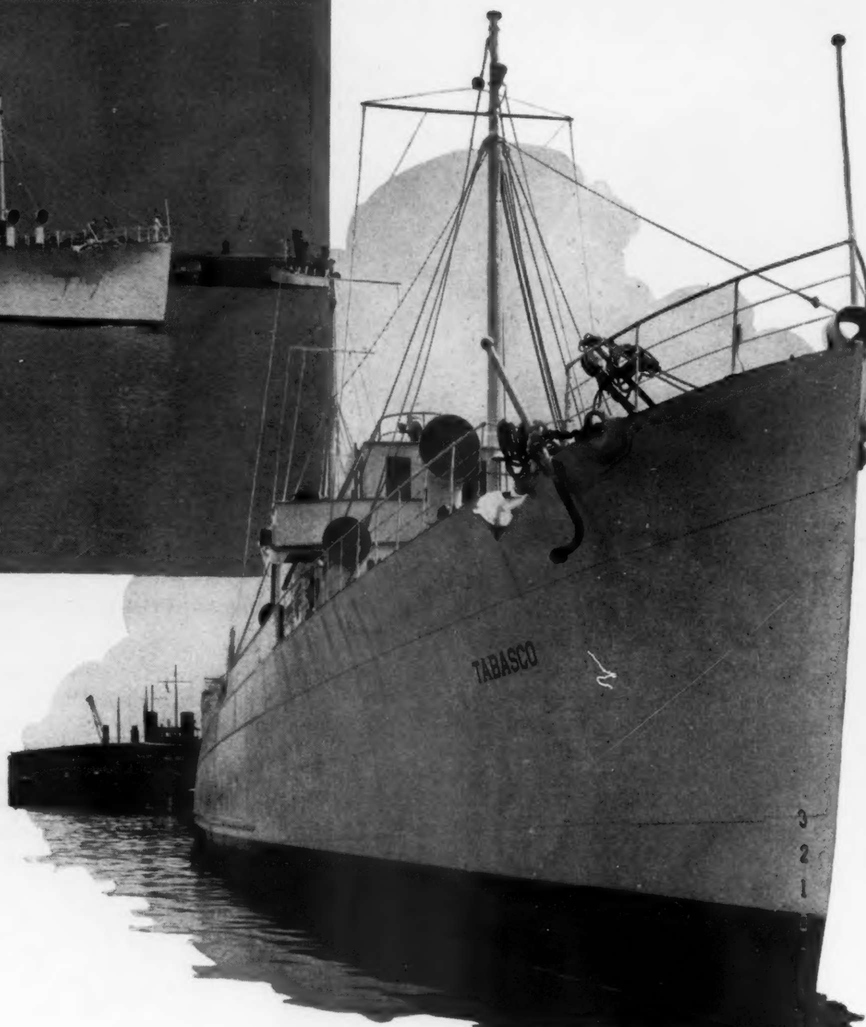
AN ANNOUNCEMENT has been made by the Allied Research Laboratories of Glendale, Calif., to the effect that they have discovered an aluminum solder suitable for repairing aluminum as well as pot metal, die castings, cast iron, steel, etc. The product is called "Alumaweld", and is said to have a tensile strength of 12,000 pounds per square inch, or more than ten times that of ordinary solder.

The manufacturers report that "Alumaweld" has two melting points: A primary one of 370° F., and a secondary one of from 50° to 250° higher, depending upon the length of time the solder has remained in the molten state. In other words, it takes a higher temperature to remelt the solder than it does to fuse it originally. It is very ductile; exceedingly malleable and yet hard enough to be worked or machined; withstands heat, steam, and water pressure; will take a polish; and can be chromium or otherwise plated.

"Alumaweld" is applied with an ordinary soldering iron or blow torch. In the case of aluminum, pot metal, and die castings it is used without a flux: for cast iron and steel a special flux is required. The solder breaks down the structure of the metal being repaired and fuses with it to form a single piece.

Cement and crushed stone are combined by what is claimed to be an entirely new process to form an artificial building material that is being sold by the Benedict Stone Products Company of Chicago, Ill., under the name of Vibraostne. It is said to be light, durable, and to have a compressive strength of more than 10,000 pounds per square inch.





Two views of the "Tabasco" as converted into a banana boat.

Destroyers That Now Carry Bananas

TWO years ago, the U. S. Destroyer *Putnam* fairly bristled with naval efficiency. Trim of line, shallow of draft, and with virtually her entire hold given over to a power plant, she could cleave the water at a 35-knot clip. This greyhound of the seas carried four 4-inch guns, a 3-inch anti-aircraft gun, and four triple torpedo tubes. Last December this once proud fighting ship, stripped of armament and rechristened the *Teapa*, entered New York Harbor as an unobtrusive cargo boat of the Vaccaro Line of New Orleans. Her bleak battleship gray had given way to a pleasing white. A new superstructure rose from her deck, and other external changes were apparent. Below deck, she carried 20,000 stems of bananas, loaded in Honduras less than a week before. As an instrument of warfare and destruction, the *Putnam* no longer exists, but as a peaceful purveyor of food she promises to live a long and useful life.

The destroyer *Worden*, a sister ship of the *Putnam*, has been similarly converted and is now the *Tabasco*. Two additional destroyers are in process of conversion. All four will be used regularly by the Vaccaro Line in the banana-carrying trade between Central American plantations and various cities of the United States as far north as Boston.

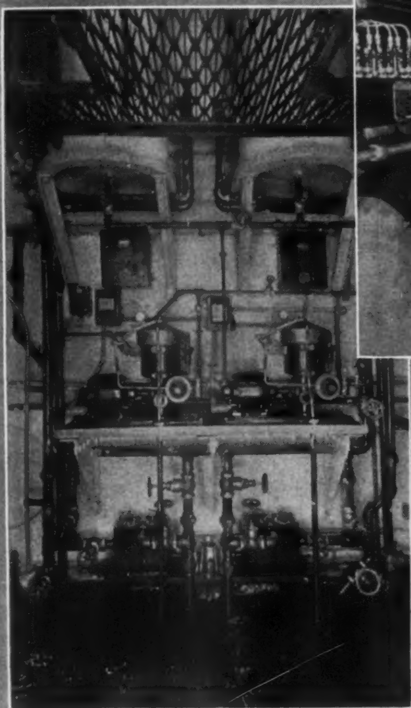
The story of how this transformation came about goes back to the signing of the treaty of limitation and reduction of naval armament in London on April 22, 1930. Under the terms of that pact, the United States was obligated to reduce its 293,000 tons of destroyers to 150,000 tons. The excess tonnage was to be scrapped or converted into hulks by December 31, 1936. In partial compliance with this agreement, the Government ordered the sale of 58 destroyers totaling 60,862 tons. The Vaccaro Line bought four of these boats after they had been reduced to hulks.

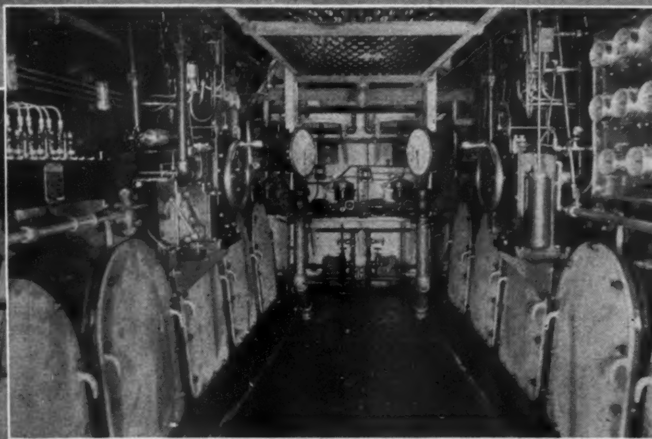
These destroyers were built in 1918, and were of the flush-deck type used exclusively for the 35-knot class constructed during the war period. Each vessel was powered with 27,500 shaft horsepower. Each of the two propeller shafts was driven through a reduction gear by high-pressure and low-pressure turbines of the Parsons type. Each shaft was served by a separate engine room containing turbines, reduction gear, and main and auxiliary condensers. There were also two boiler rooms, each equipped with two oil-fired boilers. Each boiler had fourteen burners and was designed for 260 pounds operating pressure. Each destroyer was manned by eight commissioned officers, eleven petty officers, and a crew of 114.

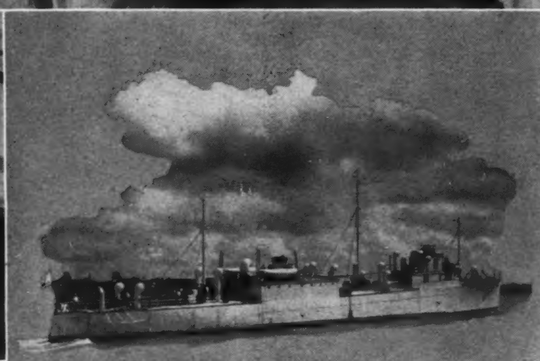
In deciding to purchase and to convert the four vessels, the present owners were influenced not only by the low first cost of the hulls but also by their many favorable features for the intended service. In the first place, their shallow draft would permit them to navigate some of the rivers in the tropics and thereby reduce handling and loading charges on bananas. In the second place, their fine lines promised maximum speed at minimum effort. This point opened the possibility of securing sufficient speed at a reasonable cost to permit the transportation of bananas direct from Central American to North Atlantic ports without employing refrigeration. This, obviously, would bring about a material saving.

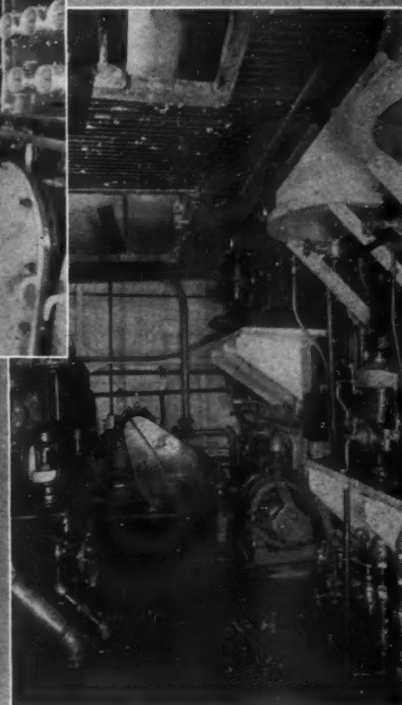
Diesel engines were decided upon for power because, in addition to their dependability and efficiency, they offered the lowest possible operating costs and because they would require only a small portion of the cargo space below deck. After the removal of the propelling machinery, war gear, shafting, propellers, and struts, and inspection by the Navy Department, the hulls of the four vessels were towed to New Orleans for reconditioning by the Todd Engineering Dry Dock & Repair Company of that city.

As reconditioned, the *Teapa* and the *Tabasco* are each equipped with two Ingersoll-









Oil filters and purifiers in the engine room.

Looking down the aisle between the main engines.

A view along the engine-room port aisle.

Rand 6-cylinder, 16x24-inch, single-acting, solid-injection diesel engines. Each engine develops 750 b.hp. at 270 revolutions per minute and is direct connected to one of the twin propeller shafts. The other two boats being converted will have engines of similar type but of 1,000 hp. rating.

Since being placed in service, the *Teapa* and the *Tabasco* have fully lived up to expected performances. After six round trips between New Orleans and Honduras, the *Teapa* made her maiden voyage to New York. On that occasion she covered the 1,800 miles from Ceiba in 103 hours and 26 minutes. Her average speed of 15½ knots was even higher than had been anticipated. Only one stop was made en route, a halt of twenty minutes to permit the repair of a leaky pipe. With their additional 500 hp., it is assured that the two boats soon to go into service will show even better speed records. The *Teapa* made her first long trip with notable economy of fuel oil. From New Orleans to Ceiba, and thence to New York, she consumed only 171 barrels for both main engines and auxiliaries.

The compactness of the engines permits the utilization of the major portion of the hold for cargo. As refitted, the space has been divided into four compartments, each served by a hatch. Cargo-handling equipment consists of four gasoline-engine-driven, reversible winches, each capable of handling 4,000 pounds at a speed of 120 feet per minute.

The original deck houses were removed when the vessels were dismantled. In their places, a forward and an after house were erected. These provide living quarters for the personnel, dining saloon, mess hall, galley, storeroom, wireless room, wheelhouse, and cabins for two passengers. Besides her master, the *Teapa* carries a crew of seventeen men, less than one-seventh of her complement when in commission as a destroyer.

In addition to the main engines, the equipment of each boat includes an Ingersoll-Rand 2-cylinder, 8¼x12-inch diesel engine direct connected to a 35-kw. Westinghouse generator. There is also a 15-kw. General Electric generator driven by a Novo 4-cylinder gasoline engine. Compressed air for starting the engines is provided by either one of two Ingersoll-Rand Type 20, two-stage compressors of 5&2½x4-inch size. One unit is driven by an electric motor and the second by a Novo gasoline engine.

Other auxiliary equipment installed includes the following:

A Cameron 300-gallon-per-minute centrifugal pump which serves as an auxiliary water circulator for the main engines.

Two Dean Brothers 6x6-inch motor-driven horizontal duplex pumps. One is used as a fire pump and the other for bilge and general service pumping.

A Viking twin oil-pump outfit consisting of two 90-gallon-per-minute rotary pumps driven by a single motor. One of these pumps is used for the transfer of fuel oil and the other for emergency service in circulating lubricating oil for the main engines.

Two Roper rotary pumps, one a sanitary unit and the other for handling fresh water.

Four Hydroil oil purifiers—two for fuel oil and two for lubricating oil.

One 15-hp., oil-fired boiler for heating purposes.

Approximate dimensions of each of the four boats are: length, 315 feet; width, 31 feet; depth, 21 feet. The cargo capacity is 20,000 stems of bananas. As reconditioned, the *Teapa* and the *Tabasco* each has a gross tonnage of 1,184 and a net tonnage of 704. Each draws slightly more than 10 feet of water.

The *Teapa* and the *Tabasco* are so distinctly different in appearance from the heavier, slower moving ships ordinarily used in the banana trade that their presence in Honduras always occasions great interest among the natives. The first few times they touched the shores of the banana country they were visited by an almost continual stream of sight-seers. At New Orleans, many people have mistaken them for yachts and have been greatly surprised to see bananas being unloaded from them.

The larger, steam-driven ships customarily used in the banana-freighting service carry as many as 80,000 stems of bananas. Because they are relatively slow moving, however, they must employ refrigeration. This not only adds to the cost of transportation but there is also some ground for the belief that it encourages quicker decay of the fruit after it is landed. The converted destroyers which have been described depend only upon blowers and deck ventilators for cooling. The temperature is prevented from falling below 55° F. in the wintertime by heating the cargo holds with steam.

How a house already standing is insulated with rock wool against cold and heat.

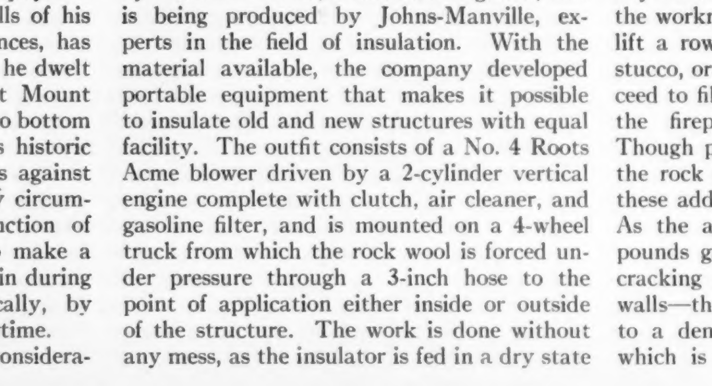
Warm in Winter—Cool in Summer

GEORGE Washington, could he again take up his abode at Mount Vernon, would be surprised at the degree of physical comfort to be found within the walls of his home that, to all outward appearances, has undergone no change since the days he dwelt there. The reason for this is that Mount Vernon has been insulated from top to bottom with rock wool to help protect this historic mansion and its invaluable contents against the ravages of fire. Under ordinary circumstances, however, the primary function of this non-inflammable material is to make a house more livable by keeping heat in during the winter season and, paradoxically, by keeping heat out during the summertime.

Insulation has not had the same consideration in the home that it has had industrially. This is not strange, because the home has, until of late years, been the last place in which to install improvements or to introduce new methods. But the man who has an eye on the fuel bills of his plant has begun to realize that proper insulation—and by that is meant the covering of wall surfaces as well as steam or hot-water pipes—will do for his residence what it does for his factory.

Among the insulating materials that have latterly been introduced especially for detached dwellings is the rock wool just referred to—a silky, hairlike substance that was discovered by Charles C. Hall, a chemical engineer, and is being produced by Johns-Manville, experts in the field of insulation. With the material available, the company developed portable equipment that makes it possible to insulate old and new structures with equal facility. The outfit consists of a No. 4 Roots Acme blower driven by a 2-cylinder vertical engine complete with clutch, air cleaner, and gasoline filter, and is mounted on a 4-wheel truck from which the rock wool is forced under pressure through a 3-inch hose to the point of application either inside or outside of the structure. The work is done without any mess, as the insulator is fed in a dry state directly from the bags in which it is shipped.

In the case of old houses, which are generally built with an air space in the outer walls, the workmen either remove a few shingles or lift a row of clapboards, drill a hole in the stucco, or take out a few bricks, and then proceed to fill the space from attic to cellar with the fireproof and heat-resisting material. Though packed solidly, there are confined in the rock wool millions of tiny air cells, and these add to its effectiveness as an insulator. As the air valve is set to blow at only 2 pounds gage pressure, there is no danger of cracking or otherwise damaging the plaster walls—that low pressure compacting the wool to a density of 10 pounds per cubic foot, which is sufficient to prevent settling. As many as 15,000 pounds of the stuff, representing 500 bags, have been blown in place during an 8-hour shift. In the same way a blanket of rock wool, not less than 3⅝ inches thick, is spread throughout the entire attic area to prevent heat loss through the roof.



The upper part of the house is finished off with a thick layer of rock wool to insure more comfort within.

There are more advantages to thus insulating a structure than those already cited. For one thing, a house so protected will shut out noises more effectually than it otherwise would: for another, it is not apt to be infested with mice or vermin because there are no hollow

walls to provide means of access. This brings us down to the most important part of the story as far as the home owner is concerned. He is always interested in concrete facts and figures; and, according to The Home Insulation Company, which drives its truck up to his door and gives his house an interlining without making any alterations, he will, because of that interlining, enjoy more bodily comfort in it than he ever did before, and save money besides. In hot blistering weather, the company assures us, the temperature in a well-insulated dwelling will be from 8 to 15° F. lower than that prevailing outside its walls; and when the mercury is down, even those exposed rooms that were formerly so hard to heat can, like the rest of the habitation, be kept at a uniform, cozy temperature at a reduction in fuel bills of from 25 to 45 per cent.

WILLIAM PRELLWITZ

WILLIAM Prellwitz, chief engineer of Ingersoll-Rand Company, died April 12 at Easton, Pa. He was 63 years old, having been born in New York City on February 7, 1869.

Many abilities were combined in Mr. Prellwitz. Inventive genius, sound engineering principles, good business judgment, a lot of common sense, and an unusual capacity for working harmoniously with his fellow men were among his assets. He contributed much to the advancement of compressed-air machinery in general, but more especially to the development of the products of the company with which he spent his entire adult life.

While he was thoroughly familiar with all Ingersoll-Rand machines, he gave most of his attention to compressors and rock drills, with the result that many developments in these products are attributable to him. Numerous inventions stand to his credit, and along with his bent for mechanical design he possessed a broad-mindedness which allowed him to see merit in the creations of others. Over a span of years he made periodic trips to Europe; and out of his contacts and studies there came the application of various European ideas and methods to American practice. Recognizing the value of plate valves in compressors, he investigated their development abroad and obtained for his company the rights to manufacture the Rogler valve in this country. Similarly, he foresaw the place that turbo-blowers were destined to take in the blast-furnace industry and was quick to improve upon and to help commercialize here the European types of this equipment.

Mr. Prellwitz designed some of the first air compressors for discharge pressures above 1,000 pounds. These early units served to furnish power for operating street cars in cities and locomotives in mines. He developed the first torpedo-charger compressor used in the United States Navy. It proved so efficient that the Government requested Ingersoll-Rand Company not to patent it nor to supply foreign countries with it. These compressors were originally built for battleships, but were later applied to both cruisers and submarines. The units were designed for 3,000 pounds pressure. Subsequently, Mr. Prellwitz was closely identified with the development of high-pressure air and gas compressors for industrial purposes.

As a boy of seventeen he started work in New York as a marine draftsman. After a year of this, he entered the employ of the Delamater Iron Works, where he was engaged as a pattern maker and afterwards in the engineering department. Meanwhile he was pursuing a course in mechanical engineering in night classes at Cooper Union. When Mr. Delamater died, a clause was found in his will directing that the business be terminated. Young Prellwitz assisted in winding up his affairs, and then, on January 27, 1890, became an employee of the Sergeant Drill Company, which was located in New York City. Shortly afterwards a consolidation gave birth to the Ingersoll-Sergeant Drill Company, and plans were made to move the manufacturing plant to Easton, Pa. Mr. Prellwitz helped to lay out and to construct the new factory, which was placed in operation November 1, 1893. At that time he became chief draftsman under Chief Engineer Henry C. Sergeant. He served in that capacity until 1900, when he became chief engineer. He retained that post when the present Ingersoll-Rand Company was formed and held it continuously until his death.

William Prellwitz

He was instrumental in perfecting the Sergeant drills which established his company as one of the foremost makers of rock-drilling machinery in the United States. In 1898 he designed the first vertical, 4-stage, 2,400-pound-discharge compressor for the Metropolitan Street Railway Company of New York for operating air engines of cross-town cars.

He was a vital factor in the development of the hammer type of rock drill, of turbo-blowers, and of direct-connected electric-driven compressors. He was responsible for the clearance-control system now used on Ingersoll-Rand compressors. He had a flair for taking hold of new ideas and of making them commercially practicable. When the company was small, he frequently would design and set a price upon a piece of equipment to meet the requirements set forth in an inquiry. He would then call upon the customer, sell the machine, return to the plant, and supervise its construction.

In 1905 Mr. Prellwitz had full charge of the design and construction of the present Phillipsburg, N. J., plant of Ingersoll-Rand Company, which is the largest in the world devoted to its line of manufacturing. His capacity for teamwork was outstanding; and he had those qualities of fairness which won him respect from all who had dealings with him. Among his coworkers and throughout his organization he was affectionately known as "Pop" Prellwitz. The following tribute from an associate of years' standing, who was thrown with him through the merger of the Ingersoll-Sergeant and Rand interests, gives a true insight into his character and qualifications:

"'Pop' and I became warm friends immediately after the consolidation. Ingersoll was the larger company and in command of the situation, but 'Pop' was always so broad and fair and kind that he completely won the respect and affection of the Rand boys. He was always a company man and, I believe, did more to promote harmony and good feeling than anyone in the organization. His ability was reinforced by a long and wonderful experience and applied with a lot of good horse sense that is lacking in many brilliant engineers. Possibly his greatest service was in keeping our company from doing a lot of foolish things."

Mr. Prellwitz was active in welfare and social work both in the company and in Easton. He was a director in the Phillipsburg Development Corporation, a subsidiary company formed to build homes for employees. As a trustee and chairman of the building committee, he played an important part in the construction of the new Easton Hospital. His wide experience in planning and erecting homes and all types of office and industrial buildings resulted in a beautifully designed, soundly constructed, and cheerfully furnished structure. He derived great pleasure from his duties as chairman and took keen interest in everything brought to his attention. This interest saved the community thousands of dollars, because his mind was always far in advance of the work as it progressed. He spent much time in choosing floor coverings of appropriate patterns and colorings for the hospital and Nurses' Home; personally designed the furniture for the children's wards; planned the landscaping of the grounds, and laid out the tennis and handball courts for the use of the nurses.

He held membership in the American Society of Mechanical Engineers; belonged to numerous clubs in his home city; and was an ardent fisherman. He was a director in the First National Bank & Trust Company of Easton.

Mr. Prellwitz is survived by his widow, Mrs. Clara Prellwitz, one daughter, a step-son, a step-daughter, and a brother, Henry Prellwitz of New York.

SHANK GRINDER TRUES STRIKING ENDS OF DRILL STEEL

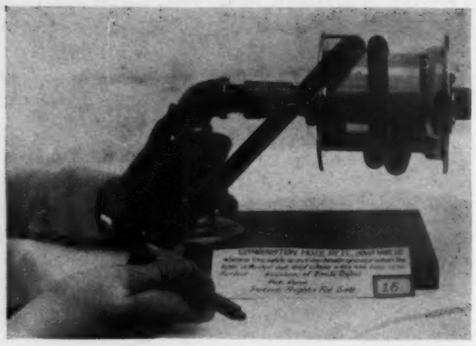
AN AIR-operated tool for facing the striking ends of drill-steel shanks, rock-drill and paving-breaker pistons, and anvil blocks has been announced by the Ingersoll-Rand Company, 11 Broadway, New York, N. Y. The 4K shank grinder, as the machine is designated, is of the "Multi-Vane" type, and is mounted in a frame so as to allow the grinding wheel to be passed back and forth by means of a handle. The mounting has a wing-nut adjustment working under spring tension for feeding the wheel up against the face being ground.

The steel or piston is held in a self-centering "V" block clamp incorporated in the frame; and a countersinking bit is located in the center of the grinding wheel for removing the burr from the hole in hollow drill steel. The complete tool can be bolted securely to the top of a work bench or other convenient place.

The 4K grinder, according to the manufacturer, insures the uniform and correct dressing of striking faces; and it eliminates rounded drill-steel shank ends and cupped pistons which are responsible for much of the spalling and breaking of these parts. Its use results in better performance of drills and paving breakers and thus reduces maintenance and replacement costs.

Squaring up the striking end of a drill steel with the 4K shank grinder.

An acidproof cement has appeared on the market that is recommended for the lining of pickling and galvanizing tanks, acid towers, etc., and for other similar services especially in the chemical industry. It comes in powdered form ready for use, and is applied like Portland cement after mixing with water. It is the product of the United States Stoneware Company, of Akron, Ohio, which claims that the cement sets fast; that it is both acidproof and waterproof; and that little expansion takes place in the joints. With the exception of hydrofluoric acid, the Pre-Mixt cement will withstand all neutral and acid solutions.



COMBINATION AIR-HOSE REEL AND AUTOMATIC VALVE

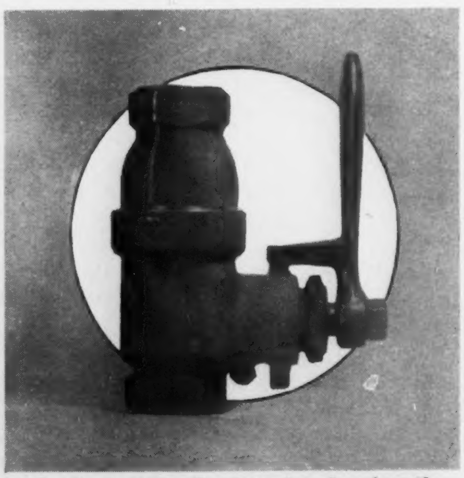
THIS ingenious little combination air-hose reel and valve was exhibited at the Inventors' Congress and New Invention Exposition held not long ago at Oakland, Calif. The valve is automatically opened the instant the air line is unreeled, and is again closed without manual aid as soon as the winding operation begins.

RUBBER IN PASTE FORM

RUBBER in paste form may now be had for a variety of industrial uses such as lining vats, tank cars, and other containers, and for covering pipes, girders, skirt boards, conveyor belts, in fact any metal, wood, concrete, or fabric surface that has to be protected against abrasion or corrosion. The compound has been put on the market by the Hitchcock Company, Inc., Boston, Mass., under the name of "Colvulc". It is said to spread readily like soft putty and to cure at room temperature, becoming an elastic sheet that no amount of expansion, contraction, or stress will crack or dislodge. It withstands extremes of heat and cold, does not become hard and brittle, and retains its elasticity indefinitely.

QUICK-ACTING AIR VALVE THAT REDUCES LEAKAGE

THE Murdock Manufacturing & Supply Company, of Cincinnati, Ohio, is introducing to industries its Q. O. C. air valve which is in use on 68 railroads. This is a quick-opening and quick-closing valve whose particular virtue lies in the fact that it is always either fully on or fully off. As a result, it is said to be impossible for operators to leave this valve partly open. Friction at the seat is eliminated, and there is, accordingly, no leakage of air.



Murdock Q. O. C. air valve showing the inlet end at the top.

The valve has a renewable disk; but, because of the absence of friction, it seldom has to be replaced. Regrinding is not required. The manufacturer claims that it will not stick, even when infrequently used, and that it always operates with the same amount of effort. It is made of red brass, except for a hard-bronze camshaft and a steel handle. Sizes range from ½ inch to 2 inches.

ALUMINUM-ALLOY BOOMS INCREASE CAPACITY OF DRAGLINES

ALUMINUM-alloy booms for any size of dragline are offered the trade by the Bucyrus-Erie Company of South Milwaukee, Wis. This announcement comes after the protracted use of a dragline with a 75-foot aluminum boom and a 1½-cubic-yard bucket by the Dick Construction Company in stripping anthracite at Hazleton, Pa. In the meantime, booms up to 175 feet in length have been put in service elsewhere and, much like their smaller predecessor, are living up to the expectations of the manufacturer.

Dragline, fitted with a 75-foot aluminum-alloy boom, stripping anthracite.

The outstanding feature of the aluminum-alloy boom is its lightness, which is obtained without a sacrifice in strength—its weight being given as two-thirds that of a steel boom of equal size. This saving makes it possible to secure a longer reach with standard buckets or to increase the size of the buckets now carried by booms of standard length.

Fireproof automobile bodies may be the next innovation to be offered by the industry, as a process has been invented for molding thin asbestos sheeting, which, besides being incombustible, is said to possess all the other qualities that are essential to that class of work.

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